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June 1966

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# RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 4 April 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

*Radiological Health Data and Reports*, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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## CONTENTS

### REPORTS

Page

Fallout from Chinese Nuclear Test of May 14, 1965 ........ 209
*S. Gold, J. Hardin, E. Tabor, H. Kreiger, B. Branson, and B. Kahn*

Comparison of Strontium-90, Iodine-131, and Cesium-137 in Milk and Milk Products ........ 215
*T. C. Reavey and E. J. Baratta*

### DATA

### SECTION I. MILK AND FOOD

National and International Milk Surveillance ........ 220
(including list of other programs previously reported)
1. Pasteurized Milk Network, December 1965, *PHS* ........ 220
2. Canadian Milk Network, December 1965 ........ 223
3. Pan American Milk Sampling Network, December 1965, *PAHO* and *PHS* ........ 224

State Milk Surveillance Activities ........ 225
(including list of other State programs previously reported)
1. Florida Milk Network, July–December 1965 ........ 225
2. Oklahoma Milk Network, August–December 1965 ........ 226
3. Texas Milk Network, April–December 1965 ........ 228

Food and Diet Surveillance Activities ........ 229
(including list of programs previously reported)

## CONTENTS—continued

Page

SECTION II. WATER ............ 230

(including list of programs previously reported)

Gross Radioactivity in Surface Waters of the United States, October 1965, *FWPCA* ............ 231

SECTION III. AIR AND DEPOSITION ............ 233

Radioactivity in Airborne Particulates and Precipitation ............ 233
(including other programs previously reported)

1. Radiation Surveillance Network, December 1965, *PHS* ............ 233
2. Canadian Air and Precipitation Monitoring Program, December 1965 ............ 234
3. Pan American Air Sampling Program, December 1965, *PAHO* and *PHS* ............ 238
4. National Air Sampling Network, October–December and Annual Summary, 1965 ............ 239

SECTION IV. OTHER DATA ............ 243

Strontium-90 in Human Bone, Deaths through 1964, *DRH* ............ 243

Environmental Levels of Radioactivity at Atomic Energy Commission Installations ............ 248

1. Bettis Atomic Power Laboratory, January–June 1965 ............ 249
2. Feed Materials Production Center, January–June 1965 ............ 250
3. Knolls Atomic Power Laboratory, January–June 1965 ............ 252
4. S1C Prototype Reactor Facility, January–June 1965 ............ 254

SECTION V. TECHNICAL NOTES

Reported Nuclear Detonations ............ 256

Synopses ............ iii

Symbols, units, and equivalents ............ inside back cover

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# SYNOPSES

**Synopses of reports are presented below in reference card format for the reader's convenience.**

**FALLOUT FROM CHINESE NUCLEAR TEST OF MAY 13, 1965.** *S. Gold, J. Hardin, E. Tabor, H. Krieger, B. Branson,* and *B. Kahn* (U.S. Public Health Service). *Radiological Health Data and Reports, Vol. 7, April 1966*, pp. 209-214.

Daily air sampling activities by the National Air Sampling Network in the latter part of May 1965 indicated the arrival of fallout attributed to the second atmospheric nuclear test by the mainland Chinese. Recently formed fallout was first detected in 24-hour samples of airborne particulates collected May 19-20, 1965, by the Helena, Montana, station. The highest gross beta activity found during the month was 7 $\text{pCi/m}^3$ at Denver, Colorado, on May 21-22. The major gamma-emitting radionuclides in the Denver samples were neptunium-239, molybdenum-99, and tellurium-132. Samples from other cities counted a week later than those from Denver contained predominantly barium-140, iodine-131, zirconium-niobium-95, cerium-141, and ruthenium-103.

Barium-140 detection in Cincinnati on May 21-22, and in New York on May 22-23, was noted in relation to the predicted arrival of fallout in the troposphere on May 19. Analyses of rain samples for barium-140 indicated deposition of fresh fallout by almost all rains occurring between May 22 and July 8.

*KEY WORDS:* Air, barium-140, cerium-141, China, fallout, fission products, gamma emitters, iodine-131, molybdenum-99, neptunium-239, niobium-95, nuclear test, radionuclides, rain, ruthenium-106, tellurium-132, zirconium--95.

**COMPARISON OF STRONTIUM-90, IODINE-131, AND CESIUM-137 IN MILK AND MILK PRODUCTS.** *T. C. Reavey* and *E. J. Baratta* (Division of Radiological Health). *Radiological Health Data and Reports, Vol. 7, April 1966*, pp. 215-218.

Distribution of strontium-90, iodine-131, and cesium-137 in series of whole milk and products representing the original milk in each series was studied. The radionuclide most affected by processing was iodine-131, which in the preparation of evaporated skim milk and nonfat dry milk was reduced to as little as 30 percent and 8 percent of the original fluid milk iodine-131 contents, respectively. While strontium-90 and cesium-137 contents of milk and milk products did not appear markedly changed by processing, cottage cheese, heavy cream, and butter retained the smallest concentrations of these radionuclides.

KEY WORDS: butter; buttermilk; cesium-137; cottage cheese: cream; dry milk; iodine-131; milk; skim milk; strontium-90.

# Reports

## FALLOUT FROM CHINESE NUCLEAR TEST OF MAY 14, 1965

*S. Gold, J. Hardin, E. Tabor, H. Kreiger, B. Branson, and B. Kahn*[1]

SYNOPSIS—Daily air sampling activities by the National Air Sampling Network in the latter part of May 1965 indicated the arrival of fallout attributed to the second atmospheric nuclear test by the mainland Chinese. Recently formed fallout was first detected in 24-hour samples of airborne particulates collected May 19–20, 1965, by the Helena, Montana, station. The highest gross beta activity found during the month was 7 pCi/m$^3$ at Denver, Colorado, on May 21–22. The major gamma-emitting radionuclides in the Denver samples were neptunium-239, molybdenum-99, and tellurium-132. Samples from other cities counted a week later than those from Denver contained predominantly barium-140, iodine-131, zirconium-niobium-95, cerium-141, and ruthenium-103.

Barium-140 detection in Cincinnati on May 21–22, and in New York on May 22–23, was noted in relation to the predicted arrival of fallout in the troposphere on May 19. Analyses of rain samples for barium-140 indicated deposition of fresh fallout by almost all rains occurring between May 22 and July 8, 1965.

In anticipation of fallout from the second atmospheric nuclear test by the mainland Chinese on May 14, 1965 (2 a.m. Greenwich time, May 14, or 10 p.m. EST, May 13), airborne particulate samples were collected daily from May 20–27 at the National Air Sampling Network (NASN) stations shown in figure 1, and at the Radiological Health Research Activities (RHRA) station in Cincinnati. On May 28, all of the NASN stations shown in figure 2 collected their regular biweekly air samples and submitted them for analysis. The arrival in the United States of fallout from this nuclear test was thus detected at ground level by the NASN and its magnitude estimated in support of radiation surveillance of the air by the Radiation Surveillance Network (RSN) (*1*).

At each station, suspended particulate matter from approximately 2,500 cubic meters of air was collected with a high-volume pump on an 8- by 10-inch glass fiber filter over a 24-hour period. After collection, the filters were removed and sent to the Robert A. Taft Sanitary Engineering Center for analysis. Gross beta activity from fallout was measured with an end-window proportional counter after the decay of the short-lived radioactive daughters of naturally occurring radon and thoron, 4 days after collection. The radioactivity concentration in picocuries per cubic meter of air was determined by:

$$A = \frac{KC}{FEV}$$

where: $A$ = concentration (pCi/m$^3$)
$K$ = 2.22 (pCi/dpm)
$C$ = count rate (cpm)
$F$ = self-absorption factor
$E$ = counter efficiency (cpm/dpm)
$V$ = air volume (m$^3$)

---

[1] Messrs. Gold, Hardin, Kreiger, and Branson are staff members, and Dr. Kahn is chief, Radiological Health Research Activities, Division of Radiological Health; Dr. Tabor is chief, National Air Sampling Network, Laboratory of Engineering and Physical Sciences, Division of Air Pollution. Both of these Divisions are agencies of the Public Health Service, U.S. Department of Health, Education, and Welfare, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

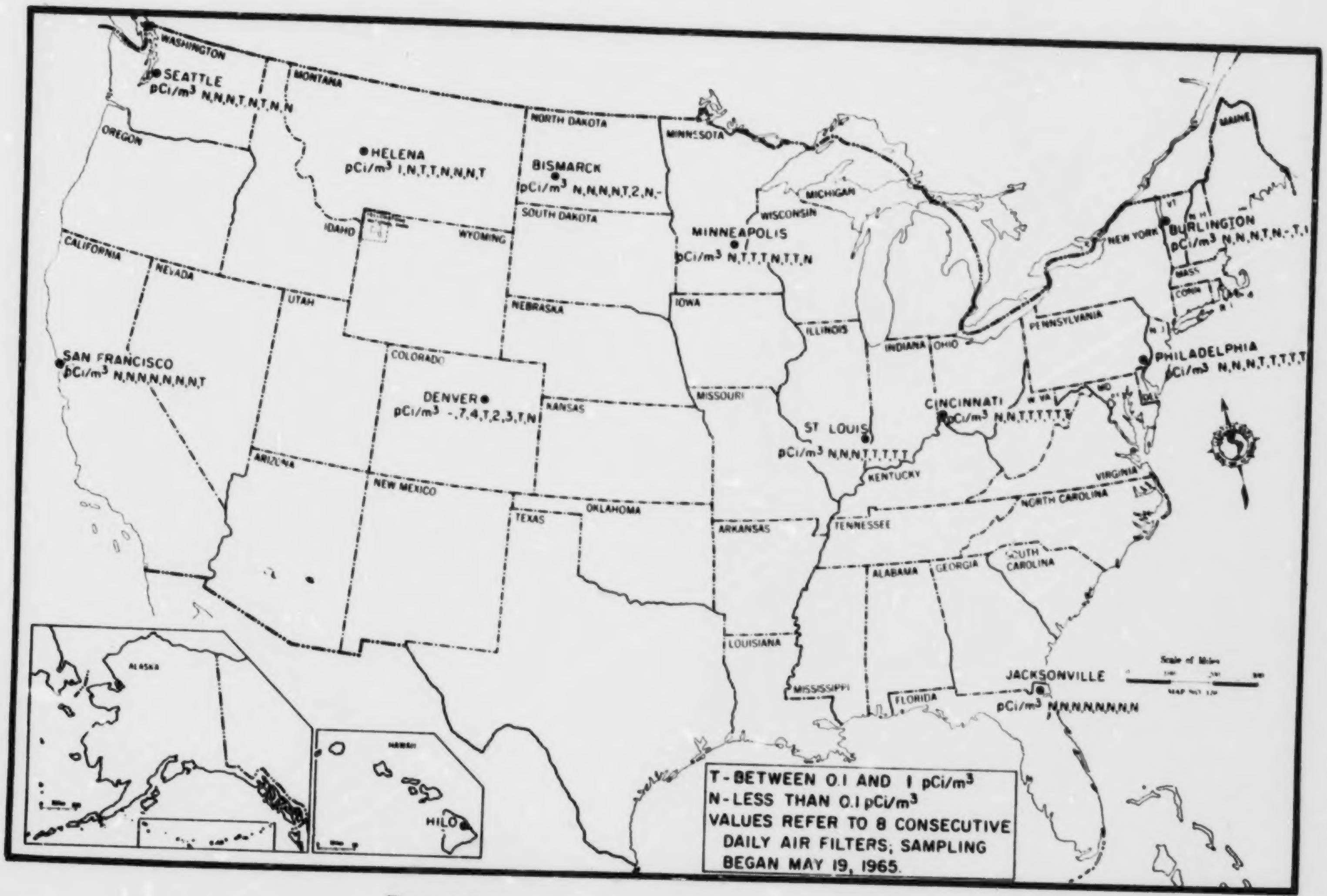
SEATTLE
pCi/m3 N,N,N,T,N,T,N,N
HELENA
pCi/m3 I,N,T,T,N,N,N,T
BISMARCK
pCi/m3 N,N,N,N,T,2,N,-
MINNEAPOLIS
pCi/m3 N,T,T,T,N,T,T,N
SAN FRANCISCO
pCi/m3 N,N,N,N,N,N,N,T
DENVER
pCi/m3 -,7,4,T,2,3,T,N
ST LOUIS
pCi/m3 N,N,N,T,T,T,T,T
CINCINNATI
pCi/m3 N,N,T,T,T,T,T,T
BURLINGTON
pCi/m3 N,N,N,T,N,-,T,I
PHILADELPHIA
pCi/m3 N,N,N,T,T,T,T,T
JACKSONVILLE
pCi/m3 N,N,N,N,N,N,N,N
HILO
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
MICHIGAN
ILLINOIS
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
W VA
MD
DEL
PENNSYLVANIA
NEW YORK
N J
VT
N H
MAINE
MASS
CONN
R I
ALASKA
HAWAII
Scale of Miles
T - BETWEEN 0.1 AND 1 pCi/m3
N - LESS THAN 0.1 pCi/m3
VALUES REFER TO 8 CONSECUTIVE DAILY AIR FILTERS; SAMPLING BEGAN MAY 19, 1965.

Figure 1. Recently formed fallout on airborne particles NASN stations and RHRA station (using glass fiber filters with air volume of approximately 2,500 m$^3$)

6

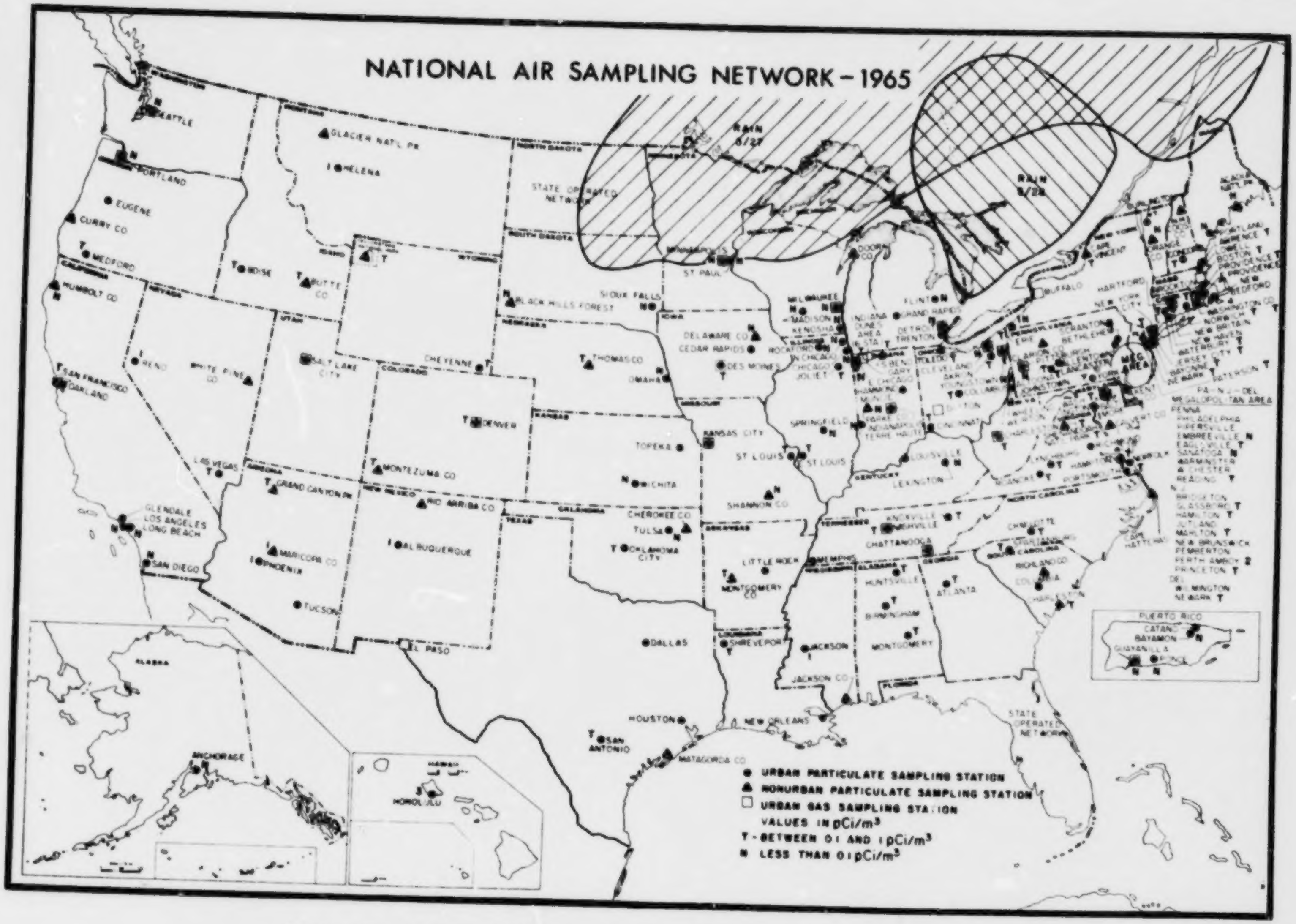
NATIONAL AIR SAMPLING NETWORK – 1965
RAIN 5/27
RAIN 5/28
STATE OPERATED NETWORK
SEATTLE
PORTLAND
EUGENE
CURRY CO
MEDFORD
HUMBOLT CO
SAN FRANCISCO
OAKLAND
RENO
WHITE PINE CO
LAS VEGAS
GLENDALE
LOS ANGELES
LONG BEACH
SAN DIEGO
BOISE
BUTTE CO
GLACIER NAT'L PK
HELENA
SALT LAKE CITY
GRAND CANYON PK
MARICOPA CO
PHOENIX
TUCSON
CHEYENNE
DENVER
MONTEZUMA CO
RIO ARRIBA CO
ALBUQUERQUE
EL PASO
BLACK HILLS FOREST
SIOUX FALLS
THOMAS CO
OMAHA
TOPEKA
WICHITA
KANSAS CITY
ST LOUIS
SHANNON CO
CHEROKEE CO
TULSA
OKLAHOMA CITY
DALLAS
HOUSTON
SAN ANTONIO
MATAGORDA CO
LITTLE ROCK
MONTGOMERY CO
SHREVEPORT
NEW ORLEANS
JACKSON
JACKSON CO
MINNEAPOLIS
ST PAUL
DELAWARE CO
CEDAR RAPIDS
DES MOINES
MILWAUKEE
MADISON
KENOSHA
ROCKFORD
CHICAGO
JOLIET
SPRINGFIELD
DOOR CO
INDIANA DUNES AREA
FLINTON
GRAND RAPIDS
DETROIT
TRENTON
TOLEDO
CLEVELAND
AKRON
COLUMBUS
CINCINNATI
LOUISVILLE
LEXINGTON
INDIANAPOLIS
TERRE HAUTE
KNOXVILLE
NASHVILLE
CHATTANOOGA
MEMPHIS
HUNTSVILLE
BIRMINGHAM
MONTGOMERY
ATLANTA
CHARLOTTE
COLUMBIA
CHARLESTON
CAPE HATTERAS
BUFFALO
HARTFORD
NEW YORK CITY
SCRANTON
BETHLEHEM
PROVIDENCE
BOSTON
NEW BEDFORD
NEW BRITAIN
WATERBURY
BAYONNE
NEWARK
PATERSON
PA-N.J.-DEL MEGALOPOLITAN AREA
PHILADELPHIA
EMBREEVILLE
SANATOGA
AXMINSTER
CHESTER
READING
BRIDGETON
GLASSBORO
HAMILTON
NEW BRUNSWICK
PEMBERTON
PERTH AMBOY
PRINCETON
WILMINGTON
NEWARK
PUERTO RICO
CATANO
BAYAMON
GUAYANILLA
PONCE
ALASKA
ANCHORAGE
HAWAII
HONOLULU
● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
□ URBAN GAS SAMPLING STATION
VALUES IN pCi/m³
T - BETWEEN 0.1 AND 1 pCi/m³
N LESS THAN 0.1 pCi/m³

Figure 2. Recently formed fallout on airborne particles collected May 27–28, 1965

After several days, the gross beta activity of the air filters was measured again to identify recently formed radionuclides by a decrease in the count rate. Gamma-emitting radionuclides were identified and measured by gamma spectral analysis with a 4- by 4-inch NaI (thallium) crystal and a 200-channel spectrometer (*2*). Errors due to counting are approximately ± 10 percent of the reported values.

The gross beta concentration of recently formed fallout given in figures 1 and 2 was estimated by subtracting 0.5 pCi/m³ from the measured value to correct for fallout from previous nuclear tests. (The concentration of 0.5 pCi/m³ was the average measured in April, when no fresh fallout was detected on airborne particules.) Concentrations between 1.0 and 0.1 pCi/m³ were recorded as trace (T), and any below 0.1 pCi/m³ as not detectable (N). The values pertain to the day of counting and were undoubtedly higher when the samples were collected.

Recently formed fallout was first detected at Helena, Montana, on the first day of collection, May 19–20. The highest gross beta activity was 7 pCi/m³ at Denver, Colorado, on May 21–22; the RSN also reported maximum concentrations in this area (*1*). Figures 1 and 2 indicate that short-lived radionuclides were detected in most parts of the United States during the latter part of May. With few exceptions, concentrations on May 27–28 were below 1.0 pCi/m³. A similar pattern of arrival from the Northwest and distribution throughout the United States within a week was observed for fallout from the first Chinese test in October 1965 (*3*).

The gamma-emitting radionuclides collected in some of the more radioactive air filters are identified in the spectra of figures 3 and 4 and quantitated in tables 1 and 2. The major constituents of the filters from Denver were 2.3-day neptunium–239, 2.8-day molybdenum–99, and 3.2-day tellurium–132. The filters from the cities listed in table 2 were counted a week

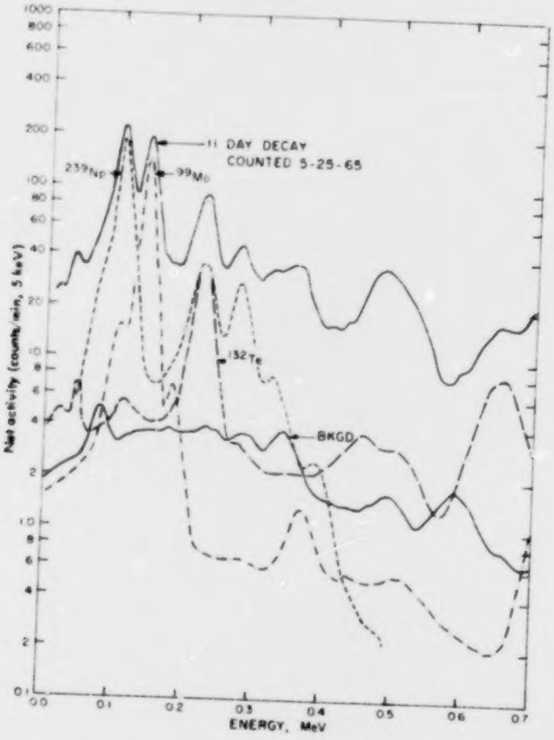

**Figure 3. Gamma spectrum of air filter collected May 20, 1965, at Denver, Colorado**

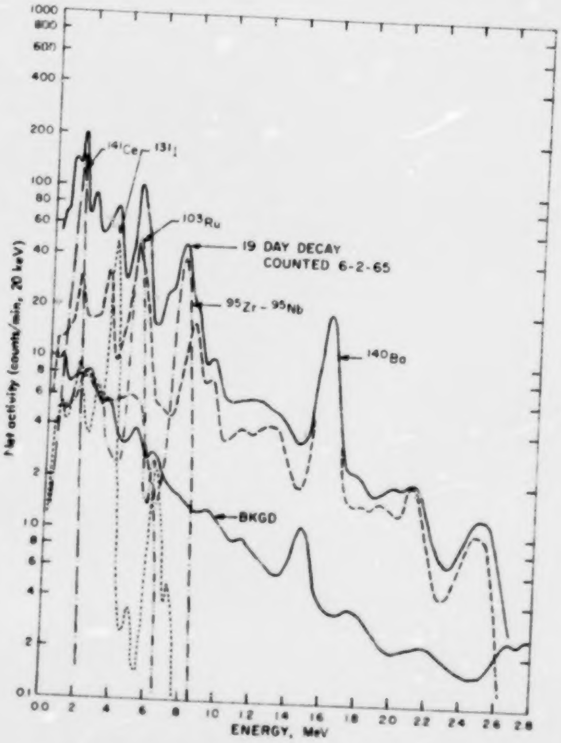

**Figure 4. Gamma spectrum of air filter collected May 27, 1965, at Honolulu, Hawaii**

**Table 1. Short-lived gamma-emitting radionuclides on airborne particles at Denver, Colorado**

| Radionuclide | Half-life (days) | Expected percent of gross beta activity, 10-day-old mixture (4) | Concentration at collection, pCi/m³ | |
|---|---|---|---|---|
| | | | 5/20/65 [a] | 5/21/65 |
| Gross beta [b] | | 100 | 6.5 | 2.9 |
| Neptunium-239 | 2.3 | — | 7.1<br>[c] (–) | 3.4<br>[c] (–) |
| Molybdenum-99 | 2.8 | 8.2 | 2.4<br>(14) | 0.80<br>(13) |
| Tellurium-132 | 3.2 | 6.1 | 0.98<br>(6.3) | 0.49<br>(8.8) |
| Barium-140 | 12.8 | 11.8 | 0.66<br>(8.2) | 0.32<br>(9.4) |
| Iodine-131 | 8.1 | 7.3 | 0.50<br>(5.4) | 0.20<br>(5.3) |
| Zirconium-niobium-95 | 65 | 4.4 | 0.60<br>(9.2) | 0.18<br>(6.2) |
| Cerium-141 | 33 | 6.4 | 0.52<br>(7.4) | 0.22<br>(7.2) |
| Ruthenium-103 | 40 | 3.2 | 0.15<br>(2.2) | 0.074<br>(2.4) |

[a] 24-hour collection period ending on this day.
[b] Recently formed fission products only, on 5/24/65.
[c] Figures in parentheses are percent of gross beta activity after correction for decay to 5/24/65.

**Table 2. Short-lived gamma-emitting radionuclides on airborne particles at Honolulu, Tucson, and Cincinnati**

| Radionuclide | Half-life (days) | Expected percent of gross beta activity, 20-day-old mixture | Concentration at collection, pCi/m³ | | |
|---|---|---|---|---|---|
| | | | Honolulu 5/27–28/65 [a] | Tucson 5/29–30/65 [b] | Cincinnati 5/23–24/65 [b] |
| Gross beta [b] | | 100 | 2.3 | 8.3 | 0.80 |
| Barium-140 | 12.8 | 12.3 | 0.46<br>[c] (14) | 1.4<br>(13) | 0.17<br>(12) |
| Iodine-131 | 8.1 | 5.6 | 0.23<br>(6.1) | 0.70<br>(5.9) | 0.089<br>(4.8) |
| Zirconium-niobium-95 | 65 | 8.3 | 0.22<br>(9.6) | 0.53<br>(6.4) | 0.063<br>(7.9) |
| Cerium-141 | 33 | 9.5 | 0.31<br>(12) | 1.1<br>(12) | 0.12<br>(12) |
| Ruthenium-103 | 40 | 4.7 | 0.19<br>(7.3) | 0.65<br>(7.3) | 0.059<br>(6.1) |

[a] 24-hour collection period ending on this day.
[b] Recently-formed fission products only, on 6/3/65.
[c] Figures in parentheses are percent of gross beta activity after correction for decay to 5/24/65.

later than those from Denver; they contained predominantly barium–140, iodine–131, zirconium-niobium–95, cerium–141, and ruthenium–103, although the shorter-lived neptunium–239, molybdenum–99, and tellurium–132 were still present. Radionuclides with half-lives longer than that of 40-day ruthenium–103 from this and previous tests were obscured in these spectra by the indicated radionuclides.

The short-lived radionuclides are all fission products except for neptunium–239, which is the daughter of 23.5-minute uranium–239, formed by the (n,$\gamma$) reaction with uranium–238. The fission product distribution approximates the distribution based on reported yields (4). Table 1 shows some fractionation, as in the higher concentrations of molybdenum–99 and zirconium-niobium–95.

To compute these values, the concentrations at the time of counting were extrapolated to the collection date. For the gross beta concentration of fresh fission products, the concentrations of old fallout (0.5 pCi/m³) and of neptunium–239 were subtracted, and the activity was then extrapolated for logarithmic decay.

The iodine–131 values given in tables 1 and 2 may be lower than actual iodine–131 concentrations in air, because a fraction of the radionuclide was gaseous rather than associated with airborne particles (5). As shown in table 3, some iodine–131 passed through the glass-fiber filter and was collected on charcoal. If the charcoal retained all of the iodine–131 that passed into the cartridge, and the relative concentrations on the filter and the charcoal were typical, one-third to one-half of the iodine–131 in the air was not collected on filters.

**Table 3. Iodine-131 in ground-level air, Cincinnati, Ohio, May 1965**

| Collection date, 1965 | Gross beta concentration 4 days after collection (pCi/m³) | | Concentration at collection (pCi/m³) | |
|---|---|---|---|---|
| | Old | Fresh | Iodine-131 filter | Iodine-131 cartridge [a] |
| 5/14–17 | 0.54 | <0.1 | <0.01 | <0.005 |
| 5/17–20 | 0.36 | <0.1 | <0.01 | <0.005 |
| 5/20–24 | 0.31 | 0.42 | 0.045 | 0.023 |
| 5/24–28 | 0.22 | 0.43 | 0.034 | 0.031 |
| 5/28–6/1 | 0.53 | <0.1 | <0.02 | 0.012 |

[a] 8-cm diameter, 2.5-cm depth, containing 85 gram charcoal; linear flow rate was 2 m/sec.

Short-lived gamma-emitting radionuclides at gross beta concentrations below 1 pCi/m³ were not so easily identifiable as those for the higher concentrations shown in figures 3 or 4, but the spectra of the mixture were distinguishable from old fallout, as shown in figure 5. The most sensitive indicator of fresh fallout was the 1.60-MeV peak of the lanthanum–140 daughter of barium–140. Consecutive daily concentrations of barium–140 at Cincinnati (table 4) show the arrival of fresh fallout on May 21–22 and its detection on almost every day until July 7–8. In addition to the daily variations in barium–140 concentration because of changes in

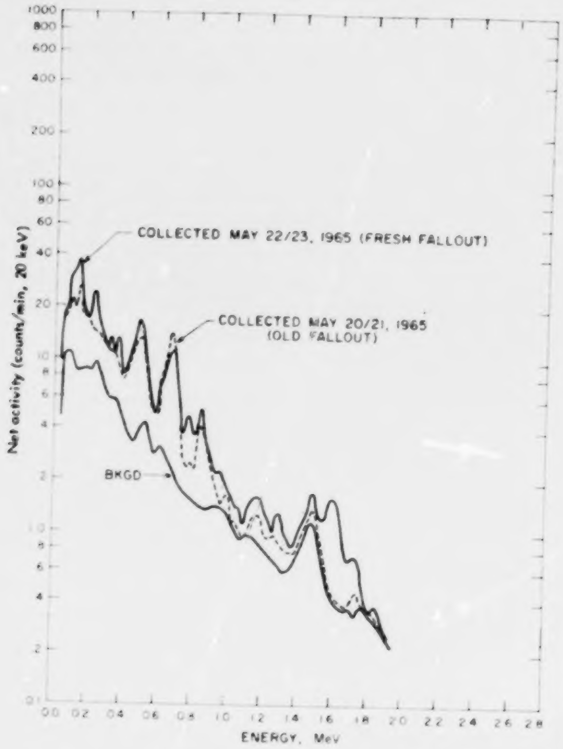

**Figure 5. Gamma spectra of air filters collected at Cincinnati, Ohio, showing old and recently formed fission products**

the weather, three broad peaks appeared, with maxima on approximately May 24, June 9, and June 22. The 2-week periods separating these maxima may be the time required for the fallout cloud to circle the globe. The initial detection on May 21–22 compares with the first appearance of barium-140 in New York on May 22–23, and the predicted arrival in the troposphere on May 19 (*5*).

Almost all of the rains occurring between May 22 and July 8 deposited fresh fallout on Cincinnati, as indicated by their barium-140 contents, listed in table 4. The deposition of this fresh fallout led to detectable iodine-131 concentrations in milk from this area during the period (*6*).

**Table 4. Barium-140 on airborne particles and in rain at Cincinnati, Ohio**

| Date 1965 [a] | Air, (pCi/m³) [b] | Rain, (pCi/liter)[b] (mm) | Date 1965 [a] | Air (pCi/m³) [b] | Rain (pCi/liter)[b] (mm) |
|---|---|---|---|---|---|
| May 20 | <0.01 | | June 17 | 0.04 | |
| 21 | <0.01 | | 18 | 0.07 | |
| 22 | 0.03 | | 19 | 0.09 | |
| 23 | 0.11 | | 20 | 0.07 | |
| 24 | 0.17 | | 21 | 0.10 | |
| 25 | 0.05 | 450 (2) | 22 | 0.14 | |
| 26 | Lost | 80 (2) | 23 | 0.13 | |
| 27 | 0.07 | | 24 | 0.09 | <10 (1) |
| 28 | 0.08 | | 25 | 0.07 | |
| 29 | 0.03 | | 26 | 0.05 | |
| 30 | <0.01 | | 27 | 0.07 | |
| 31 [c] | | | 28 | 0.04 | |
| June 1 [c] | 0.02 | 85 (2) | 29 | 0.01 | <10 (24) |
| 2 | 0.06 | 75 (10) | 30 | 0.02 | |
| 3 | 0.10 | | July 1 | 0.05 | |
| 4 | 0.01 | | 2 | 0.06 | 10 (1) |
| 5 | 0.06 | | 3 | 0.04 | |
| 6 | 0.16 | 70 (15) | 4 | 0.03 | 10 (4) |
| 7 | 0.11 | | 5 [c] | | |
| 8 | 0.16 | 60 (1) | 6 [c] | 0.03 | |
| 9 | 0.20 | | 7 | 0.03 | 10 (2) |
| 10 | 0.10 | 70 (1) | 8 | 0.01 | |
| 11 | 0.09 | 55 (10) | 9 | <0.01 | |
| 12 | 0.08 | | 10 | <0.01 | <10 (19) |
| 13 | 0.06 | | 11 | <0.01 | |
| 14 | 0.06 | | 12 | <0.01 | |
| 15 | 0.02 | | 13 | <0.01 | |
| 16 | 0.04 | | 14 | <0.01 | <10 (5) |

[a] 24-hour collection period ending on this date.

[b] Corrected for decay to date of collection. Numbers in parentheses give mm of rainfall.

[c] 48-hour collection period.

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# COMPARISON OF STRONTIUM-90, IODINE-131, AND CESIUM-137 IN MILK AND MILK PRODUCTS

*Thomas C. Reavey and Edmond J. Baratta*[1]

SYNOPSIS—Distribution of strontium-90, iodine-131, and cesium-137 in series of whole milk and products representing the original milk in each series was studied. The radionuclide most affected by processing was iodine-131, which in the preparation of evaporated skim milk and nonfat dry milk was reduced to as little as 30 percent and 8 percent of the original fluid milk iodine-131 contents, respectively. While strontium-90 and cesium-137 contents of milk and milk products did not appear markedly changed by processing, cottage cheese, heavy cream, and butter retained the smallest concentrations of these radionuclides.

A study of the levels of strontium-90, iodine-131, and cesium-137 in samples of whole milk and milk products obtained from two local processing plants serving the Boston area was conducted by the staff of the Northeastern Radiological Health Laboratory during 1962, 1963, 1964, and reported previously (*1*).

For iodine-131 comparison, four groups of samples were collected from two milk plants. The first of these groups, obtained during a period of elevated local fallout, included heavy cream, whole milk, evaporated skim milk (40 percent milk solids), and nonfat dry milk. For evaluation of strontium-90 and cesium-137, three series of samples were obtained, at one month intervals, from a second plant. These included fluid milk and six different milk products. Product samples in each group were selected to be representative of the original fluid milk.

### *Iodine-131 distribution*

The distribution of iodine-131 in the four groups of samples is shown in table 1. The measured concentrations of iodine-131 in samples of each product are listed in the second column of table 1. The data in the table are divided into four groups. The samples within each group were collected so that the activities of the samples from one group are comparable. All iodine-131 concentrations are corrected for decay to the time of collection. However, the activities of samples from one group cannot be compared to the activities from another. For example, the activities of the heavy cream sample and the whole milk sample in Group A, table 1, can be used to determine the iodine-131 carried over from the whole milk into the cream sample. However, the activity of the heavy cream sample of Group B cannot be compared to the activity of the whole milk sample of Group A. Based on the data in table 1, the relative amount of iodine-131 in each product as contrasted to the original whole milk is shown in figure 1. This figure was constructed on the basis of an assumption that the percentage distribution of activity for each of the products will be approximately the same, regardless of the activity in the original milk sample. This assumption is roughly

**Table 1. Concentrations of iodine-131 in samples of milk and milk products**

| Group | Product | Percent of original weight | Observed $^{131}$I concentration (pCi/kg)[a, b] |
|---|---|---|---|
| A | Whole milk | 100 | 261 |
| | Evaporated skim milk (40 percent milk solids) | 20 | 322 |
| | Heavy cream (40 percent butterfat) | 10 | 493 |
| | Nonfat dry milk | 8 | 228 |
| B | Heavy cream | 10 | 46 |
| | Butter | 5 | 16 |
| | Buttermilk concentrate | 1.7 | 209 |
| C | Skim milk | 90 | 82 |
| | Cottage cheese[c] | 14 | 31 |
| D | Whole milk | 100 | 81 |
| | Skim milk | 90 | 70 |

[a] Corrected for decay to time of collection.

[b] Although the analytical errors for measurements of this kind may be expected to be on the order of those reported for various milk networks, these are not presented here since normal variations in the composition of milk could outweigh the analytical error.

[c] Not creamed.

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[1] Mr. Reavey is a staff chemist and Mr. Baratta is director, Analytical Services Program, Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

borne out by the relationships shown in the analytical data. Observation of the data shows that heavy cream (40 percent butterfat) contained almost twice as much iodine–131 per kilogram as whole milk. However, since heavy cream represents only about 10 percent of the weight of the whole milk, the total content of iodine–131 in the cream was only about 20 percent of that in the milk.

The concentration of iodine–131 in evaporated skim milk (a concentrate containing 40 percent milk solids[2]) was about 25 percent greater than that in the original whole milk. Due to the weight loss by evaporation, this concentration of iodine–131 actually represents only about 30 percent of the activity in the original sample (figure 1). This indicates a direct loss of iodine–131 in the evaporation process. Continued evaporation in the process of producing nonfat dry milk, reduced the iodine–131 content still further. This loss was confirmed by the fact that only 8 percent of the iodine–131 in the original whole milk was retained in a non-fat dry milk. Raymond and Williams (*2*) reported a 40 percent loss of iodine–131 in the production of nonfat dry milk and no loss in the production of evaporated milk. This discrepancy may be accounted for by differences in manufacturing processes.

### *Strontium–90 and cesium–137 distribution*

The concentration of strontium–90 and cesium–137 in the three series of samples obtained from the second plant are shown in table 2. Calculated ratios of strontium–90 to stable calcium, and cesium–137 to stable potassium are also tabulated. As in table 1, the data of samples within a group of any one series are comparable, but data from different groups and series are not comparable. Using the same assumption as for figure 1, the relative amounts of strontium–90 in each product, as contrasted to that in the original whole milk, are shown in figure 2.

The data indicate that very small percentages of strontium–90 were retained in heavy cream, butter, and cottage cheese, as compared to the amount in the original whole milk. However, the strontium–90 to calcium ratios were essentially constant within each series of samples, indicating that strontium–90 accompanies calcium in each of the separation processes.

The distribution of cesium–137 was similar to that of strontium–90 (figure 3). The products in which the cesium–137 concentration is low are also low in stable potassium. Thus it may be concluded that cesium–137 closely follows potassium in each of the separation processes. These results and those on strontium–90 are in substantial agreement with other authors (*3–7*).

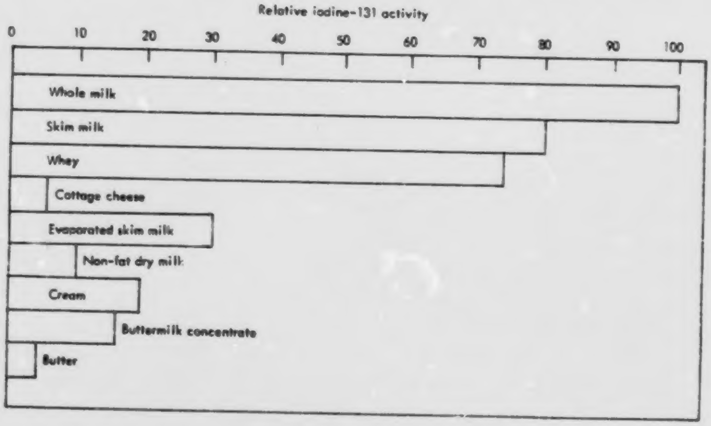

**Figure 1. Distribution of iodine–131 in milk and milk products**

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[2] Referred to as "number three condensed milk" in the industry.

Table 2. Strontium-90 to calcium and cesium-137 to potassium ratios in samples of milk and milk products [a]

| Product | Series | $^{90}Sr$ (pCi/kg) | Ca (g/kg) | Ratio of $^{90}Sr$ to Ca (pCi/g) | $^{137}Cs$ (pCi/kg) | K (g/kg) | Ratio of $^{137}Cs$ to K (pCi/g) |
|---|---|---|---|---|---|---|---|
| **Group 1** | | | | | | | |
| Whole milk | A | 38.1 | 1.13 | 34 | 296 | 1.45 | 204 |
| | B | 33.4 | 1.15 | 29 | 342 | 1.32 | 259 |
| | C | 23.0 | 1.13 | 20 | 227 | 1.33 | 171 |
| Heavy cream | A | 21.8 | 0.65 | 34 | 210 | 1.14 | 184 |
| | B | 16.8 | 0.58 | 29 | 167 | 1.04 | 161 |
| | C | 10.7 | 0.48 | 22 | 149 | 0.88 | 169 |
| Non-fat dry milk | A | 460 | 13.2 | 35 | 3,535 | 17.4 | 203 |
| | B | 380 | 13.7 | 28 | 3,268 | 17.8 | 184 |
| | C | 386 | 18.8 | 21 | 3,396 | 18.4 | 185 |
| **Group 2** | | | | | | | |
| Skim milk | A | 42.5 | 1.26 | 34 | 348 | 1.50 | 232 |
| | B | 50.0 | 1.25 | 40 | 378 | 1.60 | 236 |
| | C | 45.7 | 1.28 | 36 | 348 | 1.52 | 229 |
| Large curd (cottage cheese) | A | 21.2 | 0.60 | 35 | 104 | 0.39 | 267 |
| | B | 23.6 | 0.55 | 43 | 110 | 0.39 | 282 |
| | C | 20.6 | 0.52 | 40 | 101 | 0.38 | 266 |
| Small curd (cottage cheese) | A | 10.4 | 0.22 | 48 | 44 | 0.13 | 338 |
| | B | 16.7 | 0.39 | 43 | 128 | 0.40 | 320 |
| | C | 7.9 | 0.26 | 30 | 56 | 0.29 | 193 |
| Whey | A | 50.1 | 1.28 | 39 | 358 | 1.60 | 224 |
| | B | 54.8 | 1.27 | 43 | 399 | 1.72 | 232 |
| | C | 46.2 | 1.31 | 35 | 362 | 1.59 | 228 |
| **Group 3** | | | | | | | |
| Heavy cream | A | 17.1 | 0.57 | 30 | 162 | 0.89 | 182 |
| | B | 16.4 | 0.56 | 29 | 174 | 0.90 | 192 |
| | C | 16.5 | 0.59 | 28 | 216 | 0.96 | 225 |
| Butter | A | — | 0.09 | — | 38 | 0.22 | 173 |
| | B | 4.7 | 0.09 | 52 | 38 | 0.15 | 253 |
| | C | 4.2 | 0.14 | 29 | 80 | 0.27 | 296 |

[a] See footnote b, table 1.

## *Discussion*

The processes involved in the production of certain milk products can cause a significant reduction in their iodine–131 content. This is well demonstrated by the data for evaporated skim milk (40 percent milk solids) and nonfat dry milk, from which portions of the respective radioactive contents were lost during the evaporation process. If no iodine–131 had been lost, the evaporated skim milk would have contained about 1,000 picocuries of iodine–131 per kilogram. Since nonfat dry milk represents only 8 percent of the weight of the original whole milk, and liquid skim milk contains 80 percent of the iodine–131 in whole milk, the dry product would have contained about ten times as much iodine–131 per kilogram as the original milk, had there been no losses in the evaporation process. In this study, however, the measured iodine–131 activity of

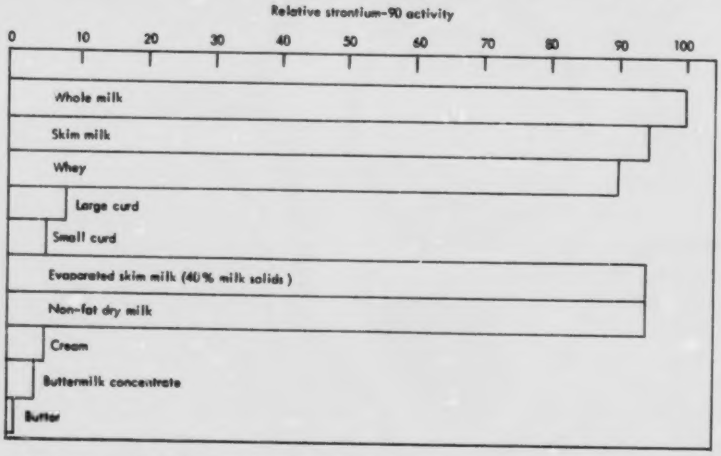

Figure 2. Distribution of strontium–90 in milk and milk products

13

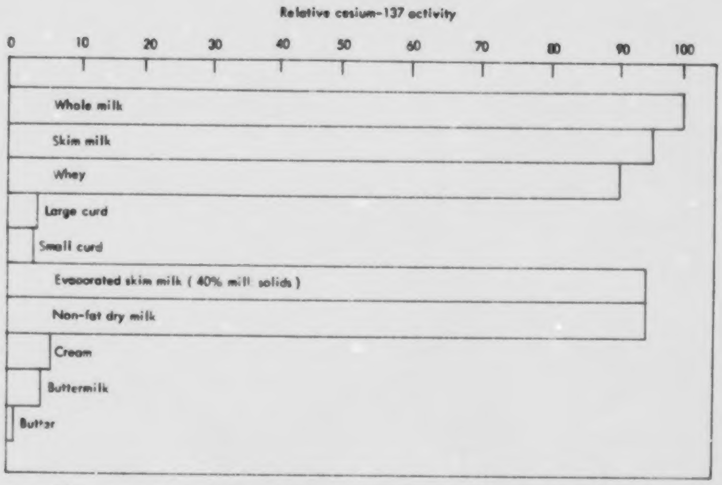

**Figure 3. Distribution of cesium-137 in milk and milk products**

the evaporated skim milk samples (table 1) was roughly equal to that of the skim milk. Based on these results, conversion of contaminated whole milk into evaporated skim milk or non-fat dry milk could be one means for reducing iodine-131 levels in times of emergency.

Since the ratio of strontium-90 to stable calcium remained almost constant in the fluid milk and its various products, it is apparent that the processes involved in their manufacture did not in any way cause a preferential loss of strontium-90. The data show that cottage cheese (small curd), heavy cream, and butter represent the products with the lesser concentrations of calcium and hence of strontium-90. In times of emergency, milk contaminated with higher levels of strontium-90 could be directed to the manufacture of these products. It is asumed that strontium levels would not be so high that these products would also be health hazards.

From the standpoint of protein or energy (calorie) requirements, Lengemann (*3*) has shown that dietary needs could be met through the substitution of cottage cheese for whole milk. Although this approach would considerably reduce the intake of strontium-90, it is important to note that the resulting diet would be inadequate in calcium. Since cesium-137 appears to follow closely the behavior of strontium-90, the amount of radiocesium in the diet would likewise be reduced if such a substitution were made. Because of the dietary need for calcium and the greater health hazard of strontium-90, however, it would appear that, in times of emergency, the utilization of milk products should be based on the intake of calcium and strontium-90 rather than cesium-137.

## *Acknowledgement*

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# Data

## Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the United States population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake. Moreover, it is the major source of dietary intake of shortlived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1, 2*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the International Commission on Radiological Protection (*4,5*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature.

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# NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

| Program | Period reported | Last presented |
|---|---|---|
| Radiostrontium in milk | January–March 1965 | September 1965 |
| United Kingdom milk | January 1961–April 1962 | October 1962 |

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## 1. Pasteurized Milk Network
## December 1965

*Division of Radiological Health*
*and Division of Environmental Engineering*
*and Food Protection, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) was designated to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 *Radiological Health Data* (*1*).

The results for December 1965 and fourth

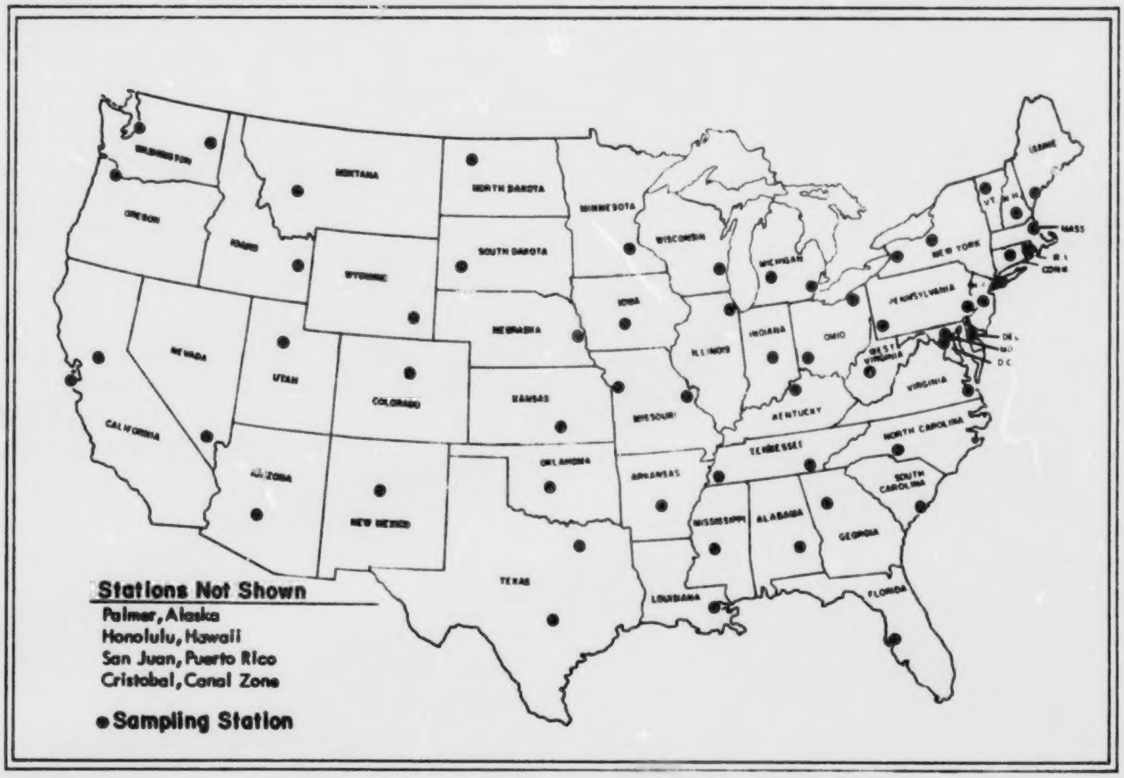

Figure 1. Pasteurized Milk Network sampling locations

**Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the fourth quarter and December 1965**[a]

| Sampling locations | | Calcium (g/liter) | | Strontium-89 (pCi/liter) | | Strontium-90 (pCi/liter) | | Cesium-137 (pCi/liter) | | Iodine-131 (pCi/liter) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fourth quarter | December 1965 | Fourth quarter | December 1965 | Fourth quarter | December 1965 | Fourth quarter | December 1965 | Fourth quarter | December 1965 |
| Ala: | Montgomery | 1.18 | 1.21 | <5 | <5 | 14 | 12 | 30 | 30 | 0 | 0 |
| Alaska: | Palmer | 1.30 | 1.23 | <5 | <5 | 15 | 20 | 55 | 70 | 0 | 0 |
| Ariz: | Phoenix | 1.25 | 1.26 | <5 | <5 | 4 | 3 | 15 | 15 | 0 | 0 |
| Ark: | Little Rock | 1.20 | 1.22 | <5 | <5 | 27 | 26 | 30 | 35 | 0 | 0 |
| Calif: | Sacramento | 1.27 | 1.30 | <5 | <5 | 4 | 4 | 15 | 20 | 0 | 0 |
| | San Francisco | 1.29 | 1.32 | <5 | <5 | 4 | 4 | 15 | 20 | 0 | 0 |
| C. Z: | Cristobal | 1.13 | 1.13 | <5 | <5 | 5 | 5 | 35 | 30 | 0 | 0 |
| Colo: | Denver | 1.28 | 1.28 | <5 | <5 | 12 | 12 | 25 | 35 | 0 | 0 |
| Conn: | Hartford | 1.12 | 1.12 | <5 | <5 | 12 | 11 | 40 | 40 | 0 | 0 |
| Del: | Wilmington | 1.15 | 1.18 | <5 | <5 | 14 | 14 | 35 | 35 | 0 | 0 |
| D. C: | Washington | 1.16 | 1.16 | <5 | <5 | 13 | 13 | 25 | 30 | 0 | 0 |
| Fla: | Tampa | 1.18 | 1.22 | <5 | <5 | 14 | 12 | 135 | 110 | 0 | 0 |
| Ga: | Atlanta | 1.17 | 1.19 | <5 | <5 | 19 | 20 | 45 | 40 | 0 | 0 |
| Hawaii: | Honolulu | 1.16 | 1.17 | <5 | <5 | 6 | 4 | 40 | 40 | 0 | 0 |
| Idaho: | Idaho Falls | 1.28 | 1.30 | <5 | <5 | 13 | 13 | 45 | 50 | 0 | 0 |
| Ill: | Chicago | 1.14 | 1.14 | <5 | <5 | 11 | 10 | 35 | 40 | 0 | 0 |
| Ind: | Indianapolis | 1.17 | 1.17 | <5 | <5 | 12 | 12 | 25 | 25 | 0 | 0 |
| Iowa: | Des Moines | 1.26 | 1.26 | <5 | <5 | 14 | 12 | 20 | 25 | 0 | 0 |
| Kans: | Wichita | 1.27 | 1.31 | <5 | <5 | 13 | 13 | 20 | 25 | 0 | 0 |
| Ky: | Louisville | 1.16 | 1.19 | <5 | <5 | 17 | 16 | 20 | 20 | 0 | 0 |
| La: | New Orleans | 1.22 | 1.23 | <5 | <5 | 30 | 29 | 40 | 40 | 0 | 0 |
| Maine: | Portland | 1.14 | 1.16 | <5 | <5 | 17 | 17 | 65 | 70 | 0 | 0 |
| Md: | Baltimore | 1.17 | 1.20 | <5 | <5 | 16 | 17 | 25 | 25 | 0 | 0 |
| Mass: | Boston | 1.15 | 1.17 | <5 | <5 | 16 | 15 | 60 | 60 | 0 | 0 |
| Mich: | Detroit | 1.12 | 1.12 | <5 | <5 | 11 | 10 | 30 | 30 | 0 | 0 |
| | Grand Rapids | 1.16 | 1.16 | <5 | <5 | 14 | 13 | 45 | 50 | 0 | 0 |
| Minn: | Minneapolis | 1.26 | 1.25 | <5 | <5 | 22 | 21 | 40 | 35 | 0 | 0 |
| Miss: | Jackson | 1.24 | 1.30 | <5 | <5 | 25 | 24 | 25 | 25 | 0 | 0 |
| Mo: | Kansas City | 1.22 | 1.23 | <5 | <5 | 16 | 14 | 20 | 20 | 0 | 0 |
| | St. Louis | 1.27 | 1.27 | <5 | <5 | 18 | 16 | 20 | 20 | 0 | 0 |
| Mont: | Helena | 1.31 | 1.34 | <5 | <5 | 15 | 16 | 45 | 50 | 0 | 0 |
| Nebr: | Omaha | 1.22 | 1.21 | <5 | <5 | 16 | 13 | 25 | 25 | 0 | 0 |
| Nev: | Las Vegas | 1.27 | 1.28 | <5 | <5 | 5 | 6 | 25 | 25 | 0 | 0 |
| N. H: | Manchester | 1.14 | 1.15 | <5 | <5 | 18 | 18 | 70 | 75 | 0 | 0 |
| N. J: | Trenton | 1.14 | 1.15 | <5 | <5 | 11 | 12 | 30 | 35 | 0 | 0 |
| N. Mex: | Albuquerque | 1.23 | 1.25 | <5 | <5 | 6 | 7 | 20 | 25 | 0 | 0 |
| N. Y: | Buffalo | 1.10 | 1.10 | <5 | <5 | 11 | 11 | 40 | 40 | 0 | 0 |
| | New York | 1.11 | 1.14 | <5 | <5 | 14 | 13 | 40 | 45 | 0 | 0 |
| | Syracuse | 1.10 | 1.11 | <5 | <5 | 12 | 12 | 35 | 40 | 0 | 0 |
| N. C: | Charlotte | 1.20 | 1.25 | <5 | <5 | 25 | 26 | 30 | 30 | 0 | 0 |
| N. Dak: | Minot | 1.27 | 1.25 | <5 | <5 | 30 | 28 | 40 | 50 | 0 | 0 |
| Ohio | Cincinnati | 1.15 | 1.16 | <5 | <5 | 13 | 11 | 20 | 25 | 0 | 0 |
| | Cleveland | 1.14 | 1.16 | <5 | <5 | 13 | 13 | 25 | 30 | 0 | 0 |
| Okla: | Oklahoma City | 1.17 | 1.18 | <5 | <5 | 14 | 13 | 20 | 20 | 0 | 0 |
| Ore: | Portland | 1.27 | 1.28 | <5 | <5 | 12 | 11 | 40 | 35 | 0 | 0 |
| Pa: | Philadelphia | 1.12 | 1.14 | <5 | <5 | 12 | 11 | 30 | 30 | 0 | 0 |
| | Pittsburgh | 1.13 | 1.11 | <5 | <5 | 17 | 17 | 40 | 45 | 0 | 0 |
| P. R: | San Juan | 1.11 | 1.11 | <5 | <5 | 9 | 9 | 30 | 25 | 0 | 0 |
| R. I: | Providence | 1.14 | 1.15 | <5 | <5 | 15 | 14 | 45 | 50 | 0 | 0 |
| S. C: | Charleston | 1.19 | 1.22 | <5 | <5 | 25 | 24 | 55 | 45 | 0 | 0 |
| S. Dak: | Rapid City | 1.23 | 1.29 | <5 | <5 | 21 | 20 | 45 | 45 | 0 | 0 |
| Tenn: | Chattanooga | 1.25 | 1.28 | <5 | <5 | 22 | 20 | 30 | 35 | 0 | 10 |
| | Memphis | 1.18 | 1.20 | <5 | <5 | 18 | 16 | 20 | 25 | 0 | 0 |
| Tex: | Austin | 1.17 | 1.20 | <5 | <5 | 6 | 6 | 10 | 10 | 0 | 0 |
| | Dallas | 1.17 | 1.20 | <5 | <5 | 12 | 11 | 20 | 20 | 0 | 0 |
| Utah: | Salt Lake City | 1.38 | 1.37 | <5 | <5 | 12 | 13 | 40 | 40 | 0 | 0 |
| Vt: | Burlington | 1.12 | 1.14 | <5 | <5 | 14 | 13 | 50 | 55 | 0 | 0 |
| Va: | Norfolk | 1.18 | 1.21 | <5 | <5 | 16 | 15 | 25 | 25 | 0 | 0 |
| Wash: | Seattle | 1.30 | 1.32 | <5 | <5 | 16 | 13 | 45 | 35 | 0 | 0 |
| | Spokane | 1.31 | 1.35 | <5 | <5 | 16 | 14 | 45 | 50 | 0 | 0 |
| W. Va: | Charleston | 1.16 | 1.16 | <5 | <5 | 16 | 15 | 20 | 20 | 0 | 0 |
| Wis: | Milwaukee | 1.20 | 1.20 | <5 | <5 | 12 | 11 | 40 | 40 | 0 | 0 |
| Wyo. | Laramie | 1.29 | 1.35 | <5 | <5 | 16 | 11 | 45 | 45 | 0 | 0 |
| Network average | | 1.20 | 1.21 | <5 | <5 | 14.6 | 13.9 | 35 | 36 | 0 | 0 |

[a] All barium-lanthanum-140 values below detectable levels.

quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

17

**Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, July–December 1965 and December 1964**

| Strontium-90 (pCi/liter) | Number of stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1965 | | | | | | 1964 |
| | July | Aug | Sept | Oct | Nov | Dec | Dec |
| Under 10 | 8 | 10 | 11 | 8 | 9 | 9 | 8 |
| 10–19 | 34 | 41 | 44 | 46 | 43 | 43 | 29 |
| 20–29 | 18 | 11 | 7 | 7 | 9 | 11 | 20 |
| 30–39 | 3 | 1 | 1 | 2 | 2 | 0 | 4 |
| 40–49 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |

**Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, July–December 1965 and December 1964**

| Cesium-137 (pCi/liter) | Number of stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1965 | | | | | | 1964 |
| | July | Aug | Sept | Oct | Nov | Dec | Dec |
| Under 50 | 34 | 45 | 50 | 54 | 57 | 51 | 9 |
| 50–99 | 25 | 16 | 12 | 8 | 5 | 11 | 38 |
| 100–149 | 3 | 1 | 0 | 0 | 1 | 1 | 14 |
| 150–199 | 1 | 1 | 1 | 1 | 0 | 0 | 2 |

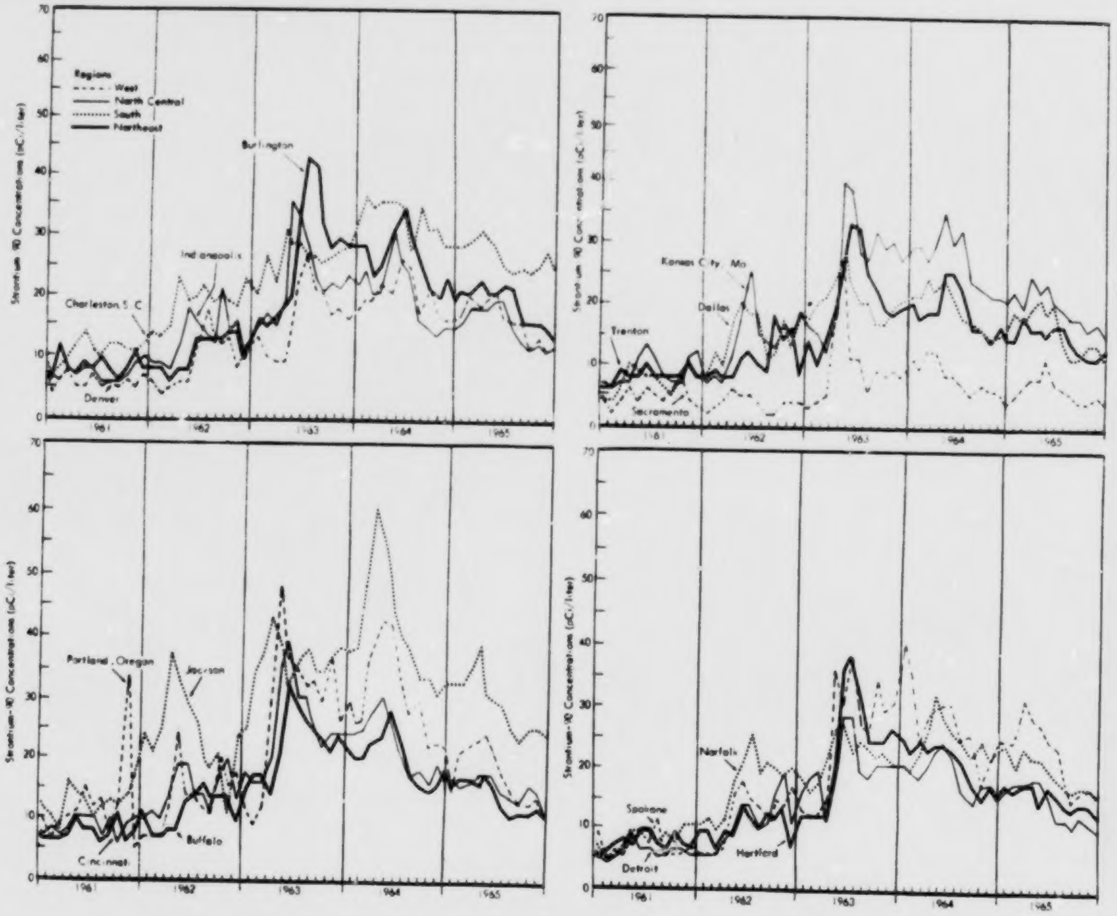

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961—December 1965

Distributions of strontium-90 and cesium-137 are presented in tables 2 and 3 for July through December 1965; for comparative purposes corresponding values for December 1964 are also shown. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

18

## 2. Canadian Milk Network December 1965[1]

*Radiation Protection Division*
*Department of National Health and Welfare*
*Ottawa, Canada*

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (2).

The December 1965 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

**Table 4. Stable elements and radionuclides in Canadian whole milk, December 1965**

| Station | Calcium (g/liter) | Potassium (g/liter) | Strontium-90 (pCi/liter) | Cesium-137 (pCi/liter) |
|---|---|---|---|---|
| Calgary | 1.15 | 1.5 | 18.7 | 70 |
| Edmonton | 1.15 | 1.5 | 19.2 | 57 |
| Ft. William | 1.10 | 1.5 | 31.8 | 76 |
| Fredericton | 1.11 | 1.6 | 26.6 | 77 |
| Halifax | 1.14 | 1.6 | 23.3 | 70 |
| Montreal | 1.09 | 1.6 | 16.3 | 45 |
| Ottawa | 1.13 | 1.6 | 13.7 | 40 |
| Quebec | 1.08 | 1.6 | 26.9 | 87 |
| Regina | 1.11 | 1.6 | 15.0 | 40 |
| St. John's, Nfld | 1.01 | 1.4 | 24.8 | 89 |
| Saskatoon | 1.11 | 1.6 | 18.1 | 42 |
| Sault Ste. Marie | 1.11 | 1.5 | 30.6 | 79 |
| Toronto | 1.16 | 1.5 | 10.0 | 38 |
| Vancouver | 1.17 | 1.5 | 19.1 | 90 |
| Windsor | 1.12 | 1.6 | 9.5 | 29 |
| Winnipeg | 1.10 | 1.4 | 17.5 | 47 |
| Average | 1.12 | 1.5 | 20.1 | 61 |

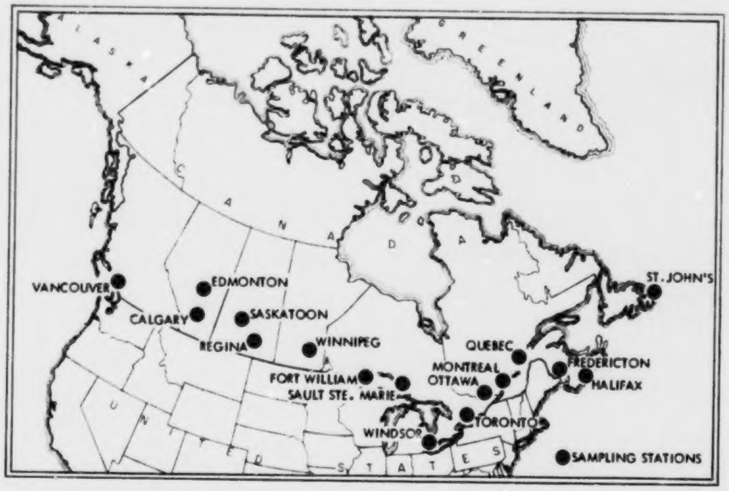

Figure 3. Canadian milk sampling stations

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[1] Prepared from January 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

## 3. Pan American Milk Sampling Program December 1965

### *Pan American Health Organization, and Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*3*).

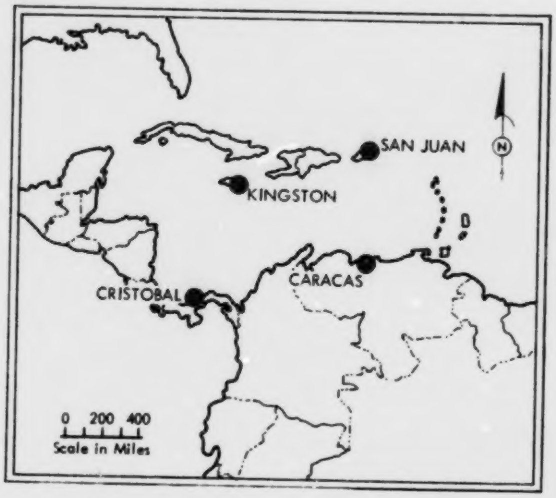

**Figure 4. Pan American Milk Network sampling locations**

Table 5 presents stable calcium and potassium, strontium-90, strontium-89, and cesium-137 monthly average concentrations. The monthly average iodine-131 and barium-140 concentrations in milk were less than 10 pCi/liter.

**Table 5. Stable elements and radionuclide concentrations in PAHO milk, December 1965**

| Sampling Station | Calcium (g/liter) | Potassium (g/liter) | Strontium-89 (pCi/liter) | Strontium-90 (pCi/liter) | Cesium-137 (pCi/liter) |
|---|---|---|---|---|---|
| Canal Zone: | | | | | |
| Cristobal | 1.13 | 1.4 | <5 | 5 | 30 |
| Jamaica: | | | | | |
| Kingston | NS | NS | NS | NS | NS |
| Mandeville | NS | NS | NS | NS | NS |
| Montego Bay | 1.22 | 1.32 | <5 | 13 | 385 |
| Puerto Rico: | | | | | |
| San Juan | 1.11 | 1.5 | <5 | 9 | 25 |
| Venezuela: | | | | | |
| Caracas | NS | NS | NS | NS | NS |

NS, no sample collected.

## REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH and DIVISION OF ENVIRONMENTAL AND FOOD PROTECTION. Milk surveillance, Pasteurized Milk Network, August 1965. Rad Health Data 6:677–681 (December 1965).

(*2*) RADIATION PROTECTION DIVISION, DEPARTMENT OF NATIONAL HEALTH AND WELFARE, OTTAWA, CANADA. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

## STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed to the level of comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein while not inclusive, are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the networks presented herein, other State networks previously covered in *Radiological Health Data and Reports* include:

| State milk network | Period reported | Last presented |
|---|---|---|
| California | July–September 1965 | March 1966 |
| Colorado | October–December 1964 and Summary 1962–1964 | April 1965 |
| Connecticut | April–September 1965 | February 1966 |
| Indiana | July–September 1965 | February 1966 |
| Michigan | July–September 1965 | February 1966 |
| Minnesota | January–June 1965 | January 1966 |
| New York | April–June 1965 | January 1966 |
| Oregon | July–September 1965 | March 1966 |
| Pennsylvania | July–September 1965 | February 1966 |
| Washington | July–September 1965 | March 1966 |

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### 1. Florida Milk Network
### July-December 1965

*Division of Radiological and Occupational Health*
*Florida State Board of Health*

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium–89, strontium–90, and cesium–137. Raw milk samples are received from the six areas shown in figure 1. Samples for iodine–131 analysis are taken from a tank truck, whose route passes by farms widely dispersed over the area represented. Where there is no route representative of a large portion of an area, samples collected

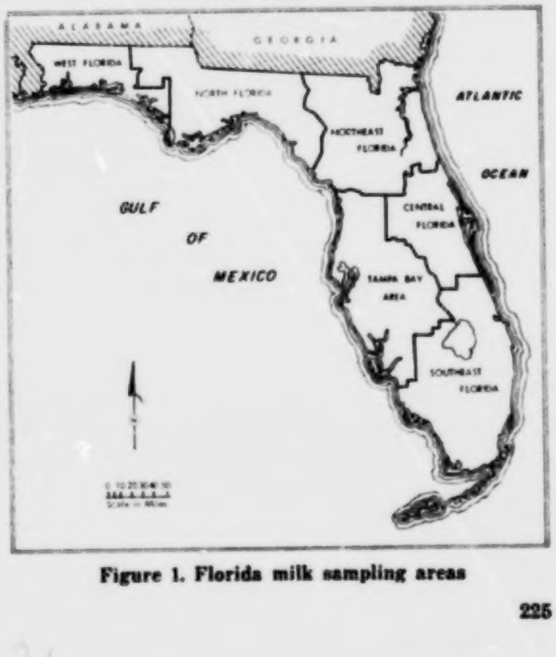

Figure 1. Florida milk sampling areas

from selected farms are combined. When iodine-131 was detectable in milk, samples were collected weekly. In the interest of maintaining an active standby capability, samples are now collected monthly for iodine analysis. A regional State Board of Health laboratory is located in each of the six areas referred to in this report. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms in the west Florida region, where locally grown feeds are used, to larger farms in the southern areas, where different types of grass and predominantly purchased feeds are used.

Strontium-89 and strontium-90 are determined by the ion exchange method developed by Porter *et al.* (*1*). Iodine-131 and cesium-137 are determined by gamma-scintillation spectrometry (*2*).

Radionuclide concentration levels for July through December 1965 are presented in tables 1 and 2. During this period, strontium-89 determinations were not performed, because of extremely low levels; and iodine-131 concentrations were below detectable levels.

**Table 1. Strontium-90 in Florida raw milk July–December 1965**

| Quarter | Analysis | Concentration (pCi/liter) | | | | | |
|---|---|---|---|---|---|---|---|
| | | West Florida | North Florida | Northeast Florida | Central Florida | Tampa Bay area | Southeast Florida |
| Third [a] | 1<br>2 | 34.1<br>37.3 | 20.6<br>23.5 | 12.7<br>13.5 | 7.2<br>6.8 | 11.6<br>11.6 | 11.0<br>10.5 |
| | Average | 35.7 | 22.1 | 13.1 | 7.0 | 11.6 | 10.8 |
| Fourth [b] | — | 22.6 | 27.4 | 12.7 | 10.1 | 11.0 | 10.7 |

[a] Duplicate analyses performed.
[b] Duplicate analysis was not possible due to insufficient sample volume

**Table 2. Cesium-137 in Florida raw milk July–December 1965**

| Month | Concentration (pCi/liter) | | | | | | |
|---|---|---|---|---|---|---|---|
| | West Florida | North Florida | Northeast Florida | Central Florida | Tampa Bay area | Southeast Florida | Average |
| July | 82 | 66 | 162 | 142 | 193 | [a] 161 | 137 |
| August | 100 | 142 | 274 | [b] 168 | 211 | 175 | 178 |
| September | 109 | [b] 77 | 188 | 204 | 226 | 161 | 148 |
| October | [b] 86 | 93 | 201 | 260 | 238 | 136 | 168 |
| November | 31 | 66 | 139 | NA | 151 | 120 | 109 |
| December | NA | NA | NA | NA | 128 | 73 | — |
| Average | [a] 80 | [a] 90 | [a] 193 | [a] 175 | 191 | 144 | — |

[a] Average calculated on the basis of incomplete data.
[b] Result represents average of two results from split samples, as part of quality control duplication.
NA, no analysis.

## 2. Oklahoma Milk Network August–December 1965

*Oklahoma State Department of Health*[1]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine-131 in milk produced in the State of Oklahoma.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 2. Of the ten milksheds in the State of Oklahoma, five were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the iodine-131 concentrations might be abnormally high.

The sampling stations are located in the laboratory of a major milk processing plant in each milkshed. While the milkshed for that particular processing plant may not coincide exactly with that shown in figure 2, the coincidence is satisfactory for surveillance purposes.

At the present time, samples are collected each Monday morning and the analyses are

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[1] Acknowledgement is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert Craig, assistant engineer.

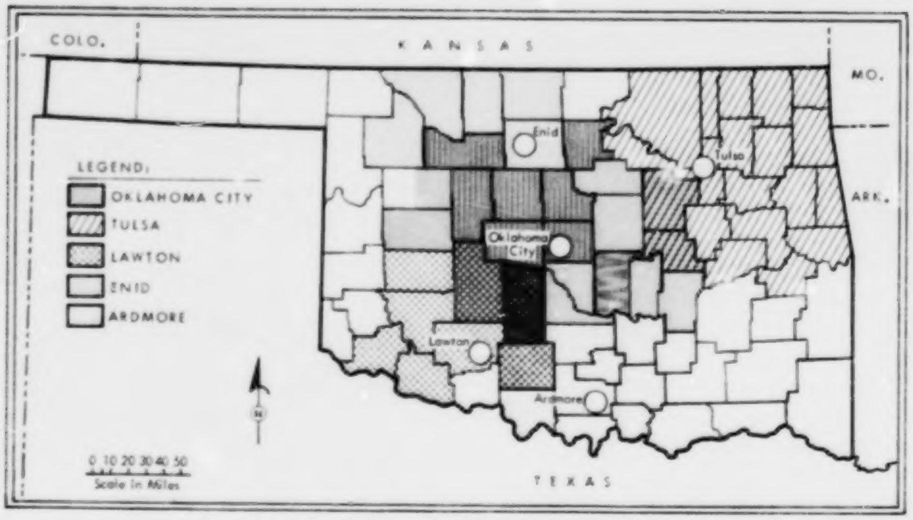

Figure 2. Oklahoma milkshed sampling areas

completed by Wednesday afternoon. However, if iodine-131 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample each truck arriving at the processing plant. Under these conditions, only about 4 hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

The ion exchange method of analysis used is similar to that recently published by the Public Health Service (3), but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory and has not been published to date. A description of the analytical procedures was presented in *Radiological Health Data* (4).

For the convenience of the reader, the sampling dates at the individual network stations are presented in table 3. During the 5-month period only one sample—that for Tulsa on October 25—showed iodine-131 activity above detectable limits.

**Table 3. Concentration of iodine-131 in Oklahoma milk, August-December 1965**

| Date, 1965 | | Concentrations (pCi/liter) | | | | |
|---|---|---|---|---|---|---|
| | | Oklahoma City | Enid | Tulsa | Lawton | Ardmore |
| August | 2 | <1 | <1 | <1 | <1 | <1 |
| | 9 | <1 | <1 | <1 | <1 | <1 |
| | 16 | <1 | NS | <1 | <1 | NS |
| | 23 | <1 | <1 | <1 | <1 | <1 |
| | 30 | <1 | <1 | <1 | <1 | <1 |
| September | 6 | <1 | NS | <1 | NS | <1 |
| | 13 | <1 | <1 | <1 | <1 | <1 |
| | 20 | <1 | <1 | <1 | <1 | <1 |
| | 27 | <1 | <1 | <1 | <1 | <1 |
| October | 4 | NS | NS | <1 | <1 | <1 |
| | 11 | <1 | <1 | <1 | <1 | <1 |
| | 18 | <1 | NS | <1 | <1 | <1 |
| | 25 | <1 | NS | 3.4 | <1 | <1 |
| November | 1 | <1 | <1 | <1 | <1 | <1 |
| | 8 | <1 | NS | <1 | <1 | NS |
| | 15 | <1 | <1 | <1 | <1 | <1 |
| | 22 | <1 | <1 | NS | NS | <1 |
| | 29 | <1 | <1 | NS | NS | NS |
| December | 6 | <1 | NS | <1 | <1 | <1 |
| | 13 | NS | <1 | <1 | <1 | <1 |
| | 20 | <1 | NS | <1 | <1 | <1 |
| | 27 | <1 | <1 | <1 | NS | <1 |

<1, below detection limit of 0.9 pCi/liter.
NS, no sample collected.

Previous coverage in *Radiological Health Data* and *Reports:*

| Period | Issue |
|---|---|
| March–July 1965 | October 1965 |

## 3. Texas Milk Network
## April–December 1965

*Texas State Department of Health*[2]

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of six "active" sampling points. In addition, six "standby" stations have been supplied sample containers and shipping instructions and can be activated immediately if needed. The "active" and "standby" station locations, shown in figure 3, were chosen to give maximum geographical and population coverage.

Table 4 presents the April through December 1965 radionuclide concentrations in Texas milk. During this time, strontium-89, iodine-131, and barium-140 concentrations were below detectable levels. Strontium-90 and cesium-137 concentrations are shown graphically in figure 4 to indicate general trends.

**Table 4. Radionuclide concentrations in Texas milk network, April–December 1965**

| Radionuclide by month, 1965 | Concentration, pCi/liter | | | | | | |
|---|---|---|---|---|---|---|---|
| | Austin | Dallas | El Paso | Harlingen | Houston | Lubbock | Average |
| Potassium-40 | | | | | | | |
| April | 1,200 | NS | 1,310 | 1,300 | 1,370 | 1,320 | 1,300 |
| May | 1,260 | NS | 1,280 | 1,280 | 1,360 | 1,250 | 1,290 |
| June | 1,350 | 1,350 | 1,250 | 1,300 | 1,340 | 1,330 | 1,320 |
| July | 1,320 | 1,370 | 1,080 | 1,330 | 1,370 | 1,280 | 1,290 |
| August | 1,310 | 1,310 | 1,110 | 1,290 | 1,390 | 1,350 | 1,290 |
| September | 1,560 | NS | 1,250 | 1,290 | 1,280 | 1,370 | 1,351 |
| October | NS | 1,330 | 1,260 | 1,280 | 1,325 | 1,320 | 1,300 |
| November | 1,330 | 1,240 | 1,400 | 1,330 | 1,290 | 1,340 | 1,320 |
| December | 1,340 | NS | 1,250 | 1,330 | 1,270 | 1,300 | 1,300 |
| Strontium-90 | | | | | | | |
| April | 6 | NS | 3 | 4 | 12 | 8 | 7 |
| May | 7 | NS | 4 | 3 | 13 | 6 | 6 |
| June | 7 | 10 | 5 | 4 | 12 | 7 | 9 |
| July | 5 | 19 | 5 | 5 | 8 | 6 | 8 |
| August | NA | 5 | 3 | 5 | 9 | 5 | 5 |
| September | 5 | NS | 9 | 5 | 7 | 9 | 7 |
| October | NS | 7 | 4 | 4 | 11 | 5 | 6 |
| November | 3 | 5 | 7 | 3 | 10 | 7 | 6 |
| December | 4 | NS | 3 | 4 | 9 | 10 | 6 |
| Cesium-137 | | | | | | | |
| April | 20 | NS | 20 | 15 | 65 | 25 | 29 |
| May | 30 | NS | 10 | 20 | 60 | 15 | 27 |
| June | 30 | 40 | 20 | 20 | 45 | 30 | 31 |
| July | 80 | 30 | 20 | 15 | 40 | 20 | 34 |
| August | 10 | 15 | 10 | 20 | 40 | 20 | 19 |
| September | 15 | NS | 15 | 10 | 25 | 15 | 16 |
| October | NS | 15 | 10 | 5 | 25 | 15 | 14 |
| November | 30 | 15 | 30 | 5 | 25 | 10 | 19 |
| December | 20 | NS | 10 | 10 | 25 | 15 | 16 |

NS, no sample collected.
NA, no analysis.

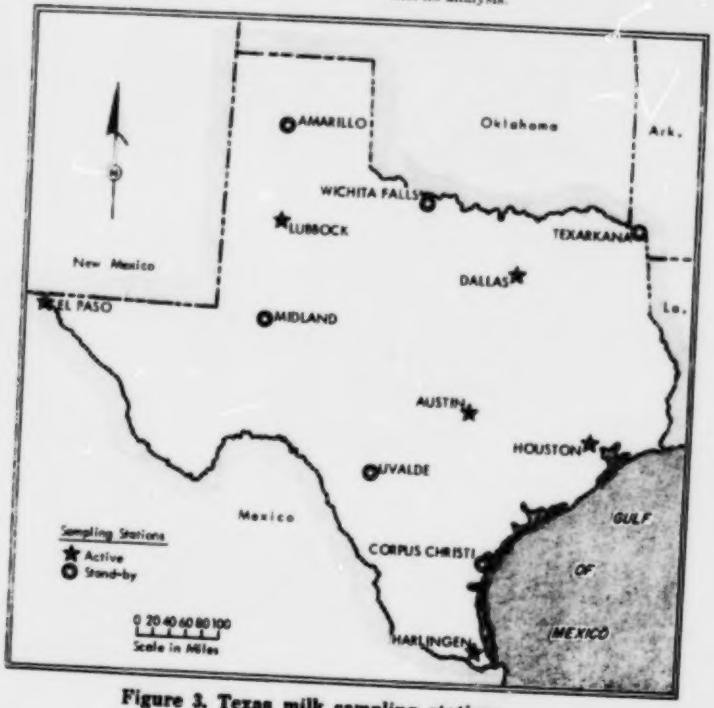

Figure 3. Texas milk sampling stations

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[2] Acknowledgement is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

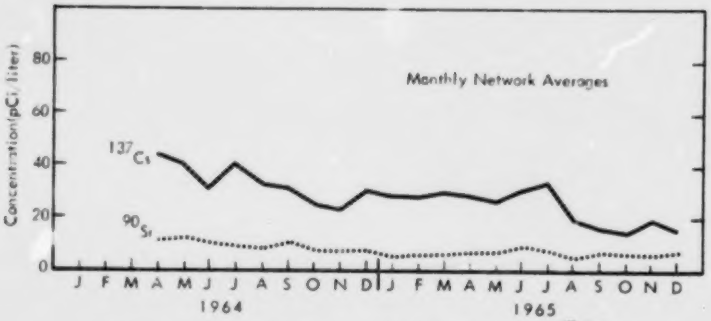

Figure 4. Radionuclide concentrations in Texas milk 1964—December 1965

Samples are routinely analyzed for strontium-89 and strontium-90 by a chemical separation technique employing ion exchange columns (*5*).

Potassium-40, iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*6*).

Previous coverage in *Radiological Health Data:*

| Period | Issue |
|---|---|
| 1964 Summary | June 1965 |
| January-March 1965 | October 1965 |

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium-90 in milk by an ion-exchange method. Anal Chem 33:1306 (September 1961).

(*2*) DIVISION OF RADIOLOGICAL AND OCCUPATIONAL HEALTH, FLORIDA STATE BOARD OF HEALTH. Florida milk network, July-December 1964. Radiological Health Data 6:611-612 (November 1965).

(*3*) PORTER, C. R., *et al.* Field method for rapid collection of iodine-131 from milk. Public Health Rep:453-456 (May 1965).

(*4*) OKLAHOMA STATE DEPARTMENT OF HEALTH. Oklahoma Milk Network, March-July 1965. Rad Health Data 6:540-541 (October 1965).

(*5*) PORTER, C., and B. KAHN. Improved determination of strontium-90 in milk by an ion exchange method. Anal Chem 36:676-678 (March 1964).

(*6*) TEXAS STATE DEPARTMENT OF HEALTH. Texas milk network, January-March 1965. Rad Health Data 6:541-542 (October 1965).

## FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. While not based on probability sampling, these networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Most recent coverage of programs reported in *Radiological Health Data and Reports* is listed below:

| Program | Period reported | Last presented |
|---|---|---|
| Institutional Total Diet | April-June 1965 | February 1966 |
| Tri-City Diet | May-July 1965 | March 1966 |
| Teenage Diet | February-November 1964 | July 1965 |
| California Diet | January-April 1965 | March 1966 |
| Connecticut Standard Diet | March 1963-December 1964 | July 1965 |

# Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the values secured with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively.

Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends.

Water programs previously reported in *Radiological Health Data and Reports* are listed below:

| Program | Period reported | Last presented |
|---|---|---|
| Radiostrontium in Tap Water, HASL | January–June 1965 | December 1965 |
| Colorado River Basin Sampling Network | 1962–1964 | November 1965 |
| Coast Guard Water Sampling Program | 1964 | November 1965 |
| Drinking Water Analysis Program | 1962 | October 1965 |
| California Water Sampling Program | January–June 1965 | March 1966 |
| Florida Water Sampling Program | 1964 | November 1965 |
| Kentucky Water Sampling Program | May 1963–June 1964 | March 1965 |
| Minnesota Surface Water Sampling Program | January–June 1965 | February 1966 |
| New York Surface Water Sampling Program | January–June 1965 | January 1966 |
| North Carolina Water Sampling Program | 1964 | November 1965 |
| Lower Columbia River Radiological Survey in Oregon | August 1963–July 1964 | October 1965 |
| Washington Surface Water Sampling Program | July 1963–June 1964 | February 1965 |

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962. PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

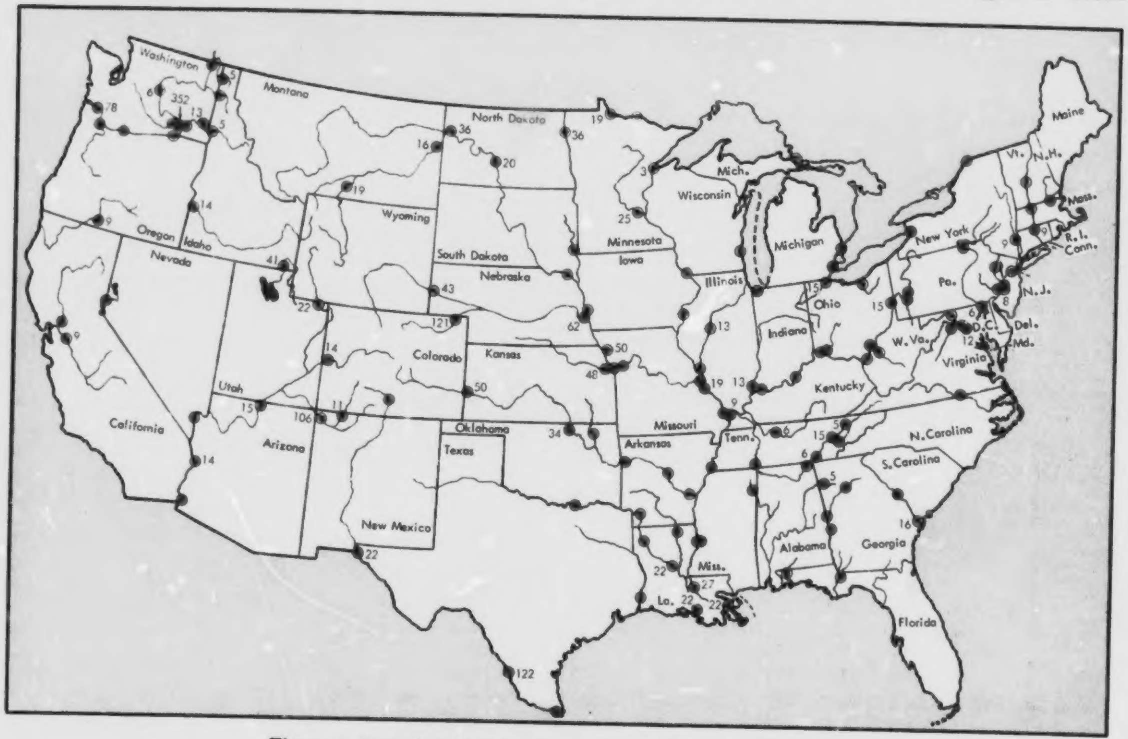
# GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, OCTOBER 1965

*Basic Data Program, Federal Water Pollution Control Administration*

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each geographical station. A description of the sampling and analytic procedures was published in the December 1965 *Radiological Health Data*.

Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. These arbitrary levels reflect no public health significance, as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes toward or from these arbitrary levels are also noted in terms of changes in radio-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Md.
D.C.
Virginia
W. Va.
Ohio
Indiana
Illinois
Iowa
Kentucky
Missouri
Tenn.
N.Carolina
S.Carolina
Georgia
Alabama
Miss.
Arkansas
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Oklahoma
Texas
Kansas
Nebraska
South Dakota
Wyoming
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New Mexico
Arizona
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**Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, October 1965**

activity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During September and October 1965, the following stations showed alpha activity in excess of 15 pCi/liter or beta activity in excess of 150 pCi/liter in either the dissolved or the suspended solids: South Platte River, Julesburg, Colorado; North Platte River, Henry, Nebraska; Arkansas River, Coolidge, Kansas; Rio Grande, Laredo, Texas; Columbia River, Pasco, Washington; and San Juan River, Shiprock, New Mexico.

The Platte River of Plattsmouth decreased in both alpha and beta activities on suspended solids but increased in alpha activity on dissolved solids from September to October.

The following stations showed a decline in alpha activity on suspended solids to values of less than 15 pCi/liter: Atchafalaya River, Morgan City, Louisiana; Arkansas River, Ponca City, Oklahoma; and Kansas River, DeSoto, Kansas.

REFERENCES

(*1*) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

**Table 1. Radioactivity in raw surface waters, October 1965 (average concentrations in pCi/liter)**

| Station | Average beta activity (pCi/liter) | | | Average alpha activity (pCi/liter) | | |
|---|---|---|---|---|---|---|
| | Suspended | Dissolved | Total | Suspended | Dissolved | Total |
| Animas River: | | | | | | |
| Cedar Hill, N. Mex | 4 | 7 | 11 | 1 | 2 | 3 |
| Arkansas River: | | | | | | |
| Coolidge, Kans | 11 | 39 | 50 | 3 | 23 | 26 |
| Ponca City, Okla | 11 | 23 | 34 | 2 | 4 | 6 |
| Atchafalaya River: | | | | | | |
| Morgan City, La | 8 | 14 | 22 | 3 | 1 | 4 |
| Bear River: | | | | | | |
| Preston, Idaho | 21 | 20 | 41 | 3 | 2 | 5 |
| Big Horn River: | | | | | | |
| Hardin, Mont | 6 | 13 | 19 | 1 | 6 | 7 |
| Chena River: | | | | | | |
| Fairbanks, Alaska | 1 | 3 | 4 | 0 | <1 | <1 |
| Clearwater River: | | | | | | |
| Lewiston, Idaho | 2 | 3 | 5 | <1 | 0 | <1 |
| Clinch River: | | | | | | |
| Clinton, Tenn | 1 | 4 | 5 | 0 | 0 | 0 |
| Kingston, Tenn | 2 | 13 | 15 | 0 | 0 | 0 |
| Colorado River: | | | | | | |
| Loma, Colo | 2 | 12 | 14 | 1 | 6 | 7 |
| Page, Ariz | <1 | 15 | 15 | 0 | 3 | 3 |
| Parker Dam, Calif-Ariz | 2 | 12 | 14 | 0 | 5 | 5 |
| Columbia River: | | | | | | |
| Wenatchee, Wash | 1 | 5 | 6 | 0 | 0 | 0 |
| Pasco, Wash | 61 | 291 | 352 | 0 | <1 | <1 |
| Clatskanie, Ore | 7 | 71 | 78 | 0 | <1 | <1 |
| Connecticut River: | | | | | | |
| Enfield Dam, Conn | 2 | 7 | 9 | 0 | 0 | 0 |
| Coosa River: | | | | | | |
| Rome, Ga | 1 | 4 | 5 | <1 | 0 | <1 |
| Cumberland River: | | | | | | |
| Cheatham Lock, Tenn | 1 | 5 | 6 | 0 | 0 | 0 |
| Delaware River: | | | | | | |
| Philadelphia, Pa | 2 | 6 | 8 | 0 | 0 | 0 |
| Great Lakes: | | | | | | |
| Duluth, Minn | 0 | 3 | 3 | 0 | 0 | 0 |
| Green River: | | | | | | |
| Dutch John, Utah | <1 | 22 | 22 | 0 | 3 | 3 |
| Hudson River: | | | | | | |
| Poughkeepsie, N.Y | 1 | 8 | 9 | 0 | 0 | 0 |
| Illinois River: | | | | | | |
| Peoria, Ill | 3 | 10 | 13 | 1 | 3 | 4 |
| Kansas River: | | | | | | |
| De Soto, Kans | 28 | 20 | 48 | 7 | 3 | 10 |
| Klamath River: | | | | | | |
| Keno, Ore | 1 | 8 | 9 | 0 | 0 | 0 |
| Maumee River: | | | | | | |
| Toledo, Ohio | 3 | 12 | 15 | 1 | 1 | 2 |
| Mississippi River: | | | | | | |
| St. Paul, Minn | 2 | 23 | 25 | 0 | 1 | 1 |
| E. St. Louis, Ill | 6 | 13 | 19 | 1 | 2 | 3 |
| New Roads, La | 19 | 8 | 27 | 6 | 1 | 7 |
| New Orleans, La | 12 | 10 | 22 | 3 | 1 | 4 |
| Missouri River: | | | | | | |
| Williston, N. Dak | 3 | 33 | 36 | 0 | 6 | 6 |
| Bismarck, N. Dak | 4 | 16 | 20 | <1 | 3 | 3 |
| St. Joseph, Mo | 27 | 23 | 50 | 8 | 4 | 12 |
| North Platte River: | | | | | | |
| Henry, Nebr | 3 | 40 | 43 | 0 | 30 | 30 |
| Ohio River: | | | | | | |
| Toronto, Ohio | 2 | 13 | 15 | 0 | 0 | 0 |
| Cairo, Ill | 1 | 8 | 9 | 0 | 0 | 0 |
| Pend Oreille River: | | | | | | |
| Albeni Falls Dam, Idaho | <1 | 5 | 5 | 0 | <1 | <1 |
| Platte River: | | | | | | |
| Plattsmouth, Nebr | 11 | 51 | 62 | 3 | 15 | 18 |
| Potomac River: | | | | | | |
| Washington, D.C | 1 | 11 | 12 | 0 | 1 | 1 |
| Rainy River: | | | | | | |
| Baudette, Minn | 3 | 16 | 19 | <1 | <1 | <1 |
| Red River, North: | | | | | | |
| Grand Forks, N. Dak | 2 | 34 | 36 | 0 | 3 | 3 |
| Red River, South: | | | | | | |
| Alexandria, La | 10 | 12 | 22 | 2 | 1 | 3 |
| Rio Grande: | | | | | | |
| El Paso, Tex | 1 | 21 | 22 | 0 | 2 | 2 |
| Laredo, Tex | 102 | 20 | 122 | 25 | 5 | 30 |
| San Joaquin River: | | | | | | |
| Vernalis, Calif | 4 | 5 | 9 | 1 | 1 | 2 |
| San Juan River: | | | | | | |
| Shiprock, N. Mex | 95 | 11 | 106 | 26 | 3 | 29 |
| Savannah River: | | | | | | |
| Port Wentworth, Ga | 3 | 13 | 16 | <1 | 0 | <1 |
| Snake River: | | | | | | |
| Payette, Idaho | 2 | 12 | 14 | 0 | 6 | 6 |
| Wawawai, Wash | 1 | 12 | 13 | 0 | 2 | 2 |
| South Platte River: | | | | | | |
| Julesburg, Colo | 32 | 89 | 121 | 10 | 66 | 76 |
| Susquehanna River: | | | | | | |
| Conowingo, Md | 0 | 6 | 6 | 0 | 0 | 0 |
| Tennessee River: | | | | | | |
| Chattanooga, Tenn | 1 | 5 | 6 | 0 | 0 | 0 |
| Wabash River: | | | | | | |
| New Harmony, Ind | 2 | 11 | 13 | 1 | 1 | 2 |
| Yellowstone River: | | | | | | |
| Sidney, Mont | 6 | 10 | 16 | 1 | 3 | 4 |
| Maximum | 102 | 291 | 352 | 26 | 66 | 76 |
| Minimum | 0 | 3 | 3 | 0 | 0 | 0 |

# Section III. Air and Deposition

## RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to the programs presented in this issue, the results of other air and deposition programs have been previously covered in *Radiological Health Data and Reports*:

| Program | Period reported | Last presented |
|---|---|---|
| HASL Fallout Network | April–December 1964 | September 1965 |
| Mexican Air Monitoring | November 1965 | March 1966 |

### 1. Radiation Surveillance Network December 1965

*Division of Radiological Health*
*Public Health Service*

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data*.

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during December 1965. Time profiles of gross beta in air dating back to 1958 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 302 air samples. No traces of fresh fission products were identified in these samples.

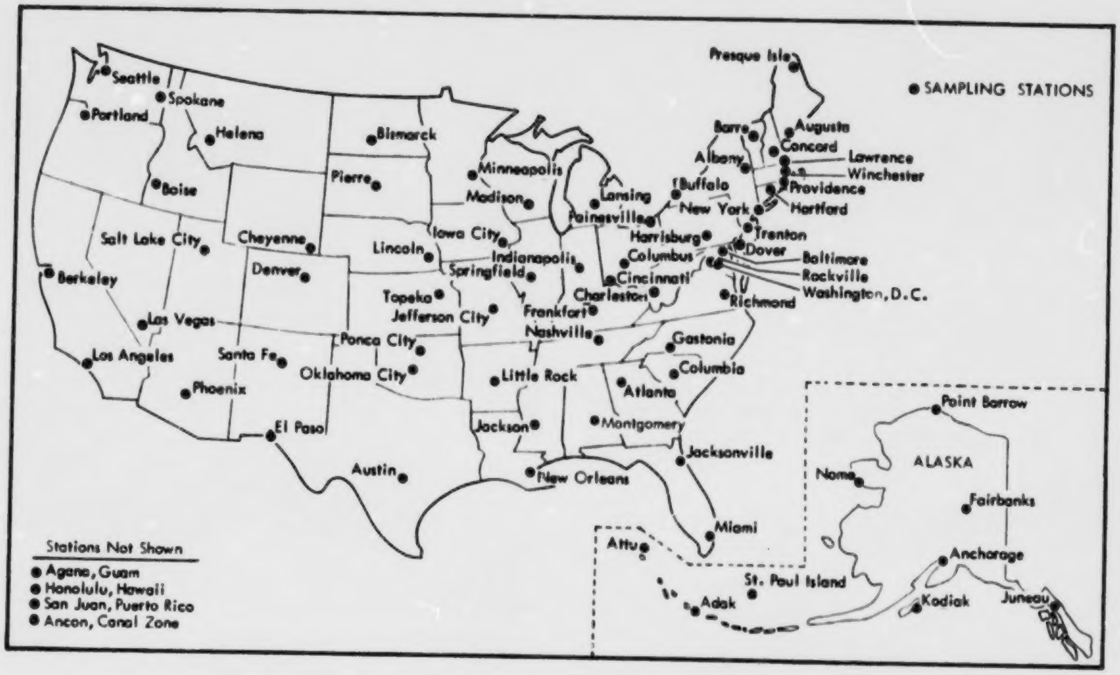
● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Berkeley
Denver
Indianapolis
Springfield
Topeka
Jefferson City
Las Vegas
Los Angeles
Santa Fe
Phoenix
Ponca City
Oklahoma City
El Paso
Austin
Little Rock
Jackson
New Orleans
Presque Isle
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Buffalo
Providence
Hartford
Lansing
Painesville
New York
Trenton
Harrisburg
Dover
Columbus
Baltimore
Rockville
Cincinnati
Washington, D.C.
Charleston
Richmond
Frankfort
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jacksonville
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

## 2. Canadian Air and Precipitation Monitoring Program December 1965[1]

*Radiation Protection Division*
*Department of National Health and Welfare*
*Ottawa, Canada*

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data*.

Surface air and precipitation data for December 1965 are presented in table 2. Specific radionuclide data are presented in table 3.

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[1] Prepared from information and data in the January 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

## Table 1. Gross beta activity in surface air and precipitation, December 1965

| Station location | | Air surveillance | | | | | | Precipitation | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number of samples | | Gross beta activity, pCi/m³ | | | Last profile in *RHD & R* | Total depth (mm) | Total deposition (nCi/m²)[a] |
| | | Air | Pptn | Maximum | Minimum | Average [a] | | | |
| Ala: | Montgomery | 30 | 5 | 0.13 | <0.10 | <0.10 | Feb 66 | 118 | <24 |
| Alaska: | Adak | 29 | | 0.12 | <0.10 | <0.10 | Sep 65 | (b) | |
| | Anchorage | 22 | | <0.10 | <0.10 | <0.10 | Mar 66 | (b) | |
| | Attu Island | 4 | | <0.10 | <0.10 | <0.10 | Oct 65 | (b) | |
| | Fairbanks | 18 | 5 | <0.10 | <0.10 | <0.10 | Apr 66 | 18 | <4 |
| | Juneau | 22 | 17 | <0.10 | <0.10 | <0.10 | Jul 65 | 200 | <40 |
| | Kodiak | 6 | | 0.12 | <0.10 | <0.11 | Aug 65 | (b) | |
| | Nome | 14 | | <0.10 | <0.10 | <0.10 | Dec 65 | (b) | |
| | Pt. Barrow | 27 | | <0.10 | <0.10 | <0.10 | Nov 65 | (b) | |
| | St. Paul Island | 13 | | <0.10 | <0.10 | <0.10 | Jan 66 | (b) | |
| Ariz: | Phoenix | 30 | | 0.19 | <0.10 | <0.11 | Jul 65 | (b) | |
| Ark: | Little Rock | 25 | 4 | 0.12 | <0.10 | <0.10 | Mar 66 | 41 | <8 |
| Calif: | Berkeley | 23 | 5 | 0.18 | <0.10 | <0.11 | Aug 65 | 85 | <17 |
| | Los Angeles | 22 | 8 | 0.18 | <0.10 | <0.11 | Dec 65 | 144 | <29 |
| C.Z: | Ancon | 17 | | <0.10 | <0.10 | <0.10 | Aug 65 | (b) | |
| Colo: | Denver | 28 | 2 | 0.18 | <0.10 | <0.11 | Aug 65 | 4 | <1 |
| Conn: | Hartford | 31 | 6 | <0.10 | <0.10 | <0.10 | Apr 66 | 42 | <8 |
| Del: | Dover | 20 | | <0.10 | <0.10 | <0.10 | Feb 66 | (b) | |
| D.C: | Washington | 31 | 2 | <0.10 | <0.10 | <0.10 | Nov 65 | 11 | <2 |
| Fla: | Jacksonville | 28 | 6 | 0.11 | <0.10 | <0.10 | Mar 66 | 108 | <22 |
| | Miami | 30 | 2 | 0.15 | <0.10 | <0.10 | Apr 66 | 15 | <3 |
| Ga: | Atlanta | (c) | 3 | | | | Jan 66 | 23 | <5 |
| Guam: | Agana | 31 | | <0.10 | <0.10 | <0.10 | Feb 66 | (b) | |
| Hawaii: | Honolulu | 30 | 7 | <0.10 | <0.10 | <0.10 | Oct 65 | 133 | <27 |
| Idaho: | Boise | 30 | 1 | 0.25 | <0.10 | <0.11 | Oct 65 | 2 | 0 |
| Ill: | Springfield | 30 | | 0.14 | <0.10 | <0.11 | Nov 65 | (b) | |
| Ind: | Indianapolis | 27 | 6 | 0.13 | <0.10 | <0.10 | Jan 66 | 46 | <9 |
| Iowa: | Iowa City | 28 | 4 | <0.10 | <0.10 | <0.10 | Aug 65 | 66 | <13 |
| Kans: | Topeka | 31 | 4 | <0.10 | <0.10 | <0.10 | Mar 66 | 44 | <9 |
| Ky: | Frankfort | 28 | 5 | 0.17 | <0.10 | <0.11 | Nov 65 | 14 | <3 |
| La: | New Orleans | 28 | 11 | <0.10 | <0.10 | <0.10 | Nov 65 | 189 | <38 |
| Maine: | Augusta | 31 | 6 | <0.10 | <0.10 | <0.10 | Dec 65 | 54 | <11 |
| | Presque Isle | 23 | | <0.10 | <0.10 | <0.10 | Aug 65 | (b) | |
| Md: | Baltimore | 21 | 2 | 0.13 | <0.10 | <0.10 | Apr 66 | 20 | <4 |
| | Rockville | 14 | | <0.10 | <0.10 | <0.10 | Oct 65 | (b) | |
| Mass: | Lawrence | 30 | 4 | 0.12 | <0.10 | <0 10 | Feb 66 | 29 | <6 |
| | Winchester | 31 | 3 | <0.10 | <0.10 | <0.10 | Sep 65 | 29 | <6 |
| Mich: | Lansing | 31 | | 0.11 | <0.10 | <0.10 | Oct 65 | (b) | |
| Minn: | Minneapolis | 23 | 5 | <0.10 | <0.10 | <0.10 | Feb 66 | 30 | <6 |
| Miss: | Jackson | 29 | 4 | <0.10 | <0.10 | <0.10 | Dec 65 | 68 | <14 |
| Mo: | Jefferson City | 29 | 8 | <0.10 | <0.10 | <0.10 | Jan 66 | 58 | <12 |
| Mont: | Helena | 31 | 3 | 0.14 | <0.10 | <0.10 | Sep 65 | 4 | <1 |
| Nebr: | Lincoln | 18 | | <0.10 | <0.10 | <0.10 | Jan 66 | (b) | |
| Nev: | Las Vegas | 26 | | 0.19 | <0.10 | <0.11 | Apr 66 | (b) | |
| N.H: | Concord | 12 | | <0.10 | <0.10 | <0.10 | Nov 65 | | |
| N.J: | Trenton | 31 | 3 | 0.11 | <0.10 | <0.10 | Dec 65 | 12 | <2 |
| N.Mex. | Santa Fe | 27 | 9 | <0.10 | <0.10 | <0.10 | Sep 65 | 34 | <7 |
| N.Y: | Albany | 21 | 4 | <0.10 | <0.10 | <0.10 | Jan 66 | 17 | <3 |
| | Buffalo | 31 | | <0.10 | <0.10 | <0.10 | Aug 65 | (b) | |
| | New York | 28 | | <0.10 | <0.10 | <0.10 | Sep 65 | (b) | |
| N.C: | Gastonia | 30 | 2 | 0.13 | <0.10 | <0.10 | Aug 65 | 10 | <2 |
| N.Dak: | Bismarck | 29 | 2 | <0.10 | <0.10 | <0.10 | Nov 65 | 6 | <1 |
| Ohio: | Cincinnati | 13 | | <0.10 | <0.10 | <0.10 | Feb 66 | (b) | |
| | Columbus | 28 | 3 | 0.15 | <0.10 | <0.11 | Dec 65 | 15 | <3 |
| | Painesville | 30 | 6 | 0.13 | <0.10 | <0.10 | Apr 66 | 36 | <7 |
| Okla: | Oklahoma City | 28 | 4 | 0.11 | <0.10 | <0.10 | Oct 65 | 63 | <13 |
| | Ponca City | 24 | 6 | <0.10 | <0.10 | <0.10 | Apr 66 | 67 | <14 |
| Ore: | Portland | 28 | 15 | 0.18 | <0.10 | <0.11 | Jan 66 | 88 | <18 |
| Pa: | Harrisburg | 29 | 2 | <0.10 | <0.10 | <0.10 | Jan 66 | 21 | <4 |
| P.R: | San Juan | 27 | 5 | <0.10 | <0.10 | <0.10 | Dec 65 | 157 | <31 |
| R.I: | Providence | 29 | 2 | <0.10 | <0.10 | <0.10 | Oct 65 | 30 | <6 |
| S.C: | Columbia | 30 | 5 | 0.14 | <0.10 | <0.10 | Sep 65 | 15 | <3 |
| S Dak: | Pierre | 31 | 1 | <0.10 | <0.10 | <0.10 | Jul 65 | 6 | <1 |
| Tenn: | Nashville | 31 | 4 | <0.10 | <0.10 | <0.10 | Oct 65 | 24 | <5 |
| Tex: | Austin | 28 | 11 | 0.11 | <0.10 | <0.10 | Feb 66 | 140 | <28 |
| | El Paso | 31 | 10 | 0.14 | <0.10 | <0.10 | Nov 65 | 22 | <5 |
| Utah: | Salt Lake City | 31 | 9 | 0.13 | <0.10 | <0.10 | Dec 65 | 42 | <9 |
| Vt: | Barre | 28 | 8 | 0.15 | <0.10 | <0.10 | Mar 66 | 37 | <8 |
| Va: | Richmond | 30 | 3 | <0.10 | <0.10 | <0.10 | Mar 66 | 7 | <2 |
| Wash: | Seattle | 29 | 18 | <0.10 | <0.10 | <0.10 | Mar 66 | 139 | <28 |
| | Spokane | 28 | 2 | 0.12 | <0.10 | <0.10 | Feb 66 | 8 | <2 |
| W. Va: | Charleston | 27 | 4 | <0.10 | <0.10 | <0.10 | Sep 65 | 7 | <2 |
| Wis: | Madison | 30 | 6 | <0.10 | <0.10 | <0.10 | Mar 66 | 63 | <13 |
| Wyo: | Cheyenne | 31 | 2 | 0.12 | <0.10 | <0.10 | Apr 66 | 5 | <1 |
| Network summary | | 1,900 | 284 | 0.25 | <0.10 | <0.10 | | 50 | <10 |

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] Indicates no precipitation sample collected. [c] Indicates no report received.

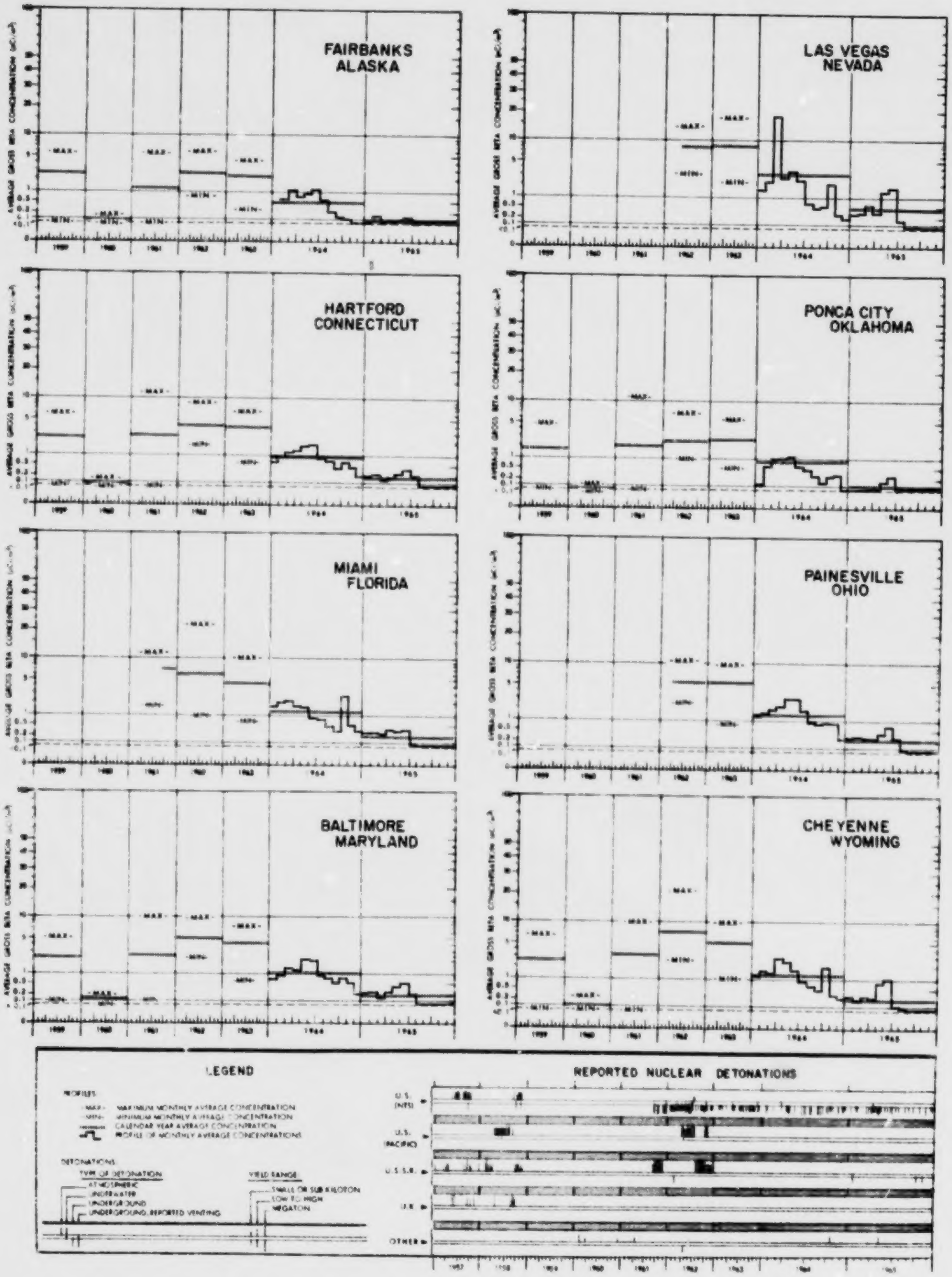

Figure 2. Monthly and yearly profiles of beta activity in air, Radiation Surveillance Network, 1959-December 1965

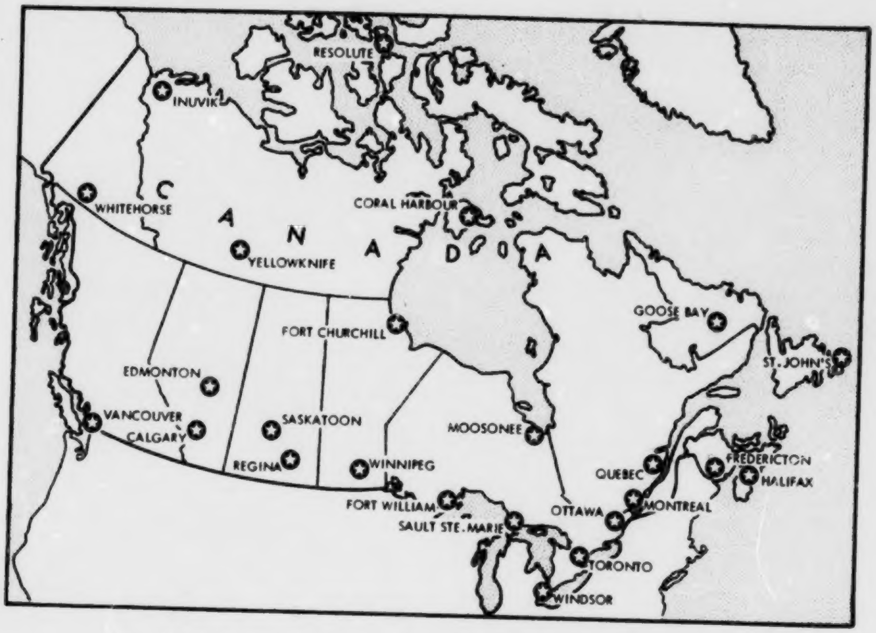
RESOLUTE
INUVIK
C
A
N
A
D
A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
OTTAWA
MONTREAL
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

**Table 2. Canadian gross beta activity in surface air and precipitation, December 1965**

| Station | Air surveillance | | | | Precipitation measurements | |
|---|---|---|---|---|---|---|
| | Number of samples | Activity (pCi/m³) | | | Average concentration (pCi/liter) | Total deposition (nCi/m²) |
| | | Maximum | Minimum | Average | | |
| Calgary | 31 | 0.2 | 0.0 | 0.1 | 67 | 0.5 |
| Coral Harbour | 31 | 0.1 | 0.0 | 0.1 | 64 | 0.6 |
| Edmonton | 31 | 0.1 | 0.0 | 0.1 | 39 | 0.7 |
| Ft. Churchill | 31 | 0.1 | 0.0 | 0.1 | 44 | 0.5 |
| Ft. William | 31 | 0.1 | 0.0 | 0.1 | 25 | 1.3 |
| Fredericton | 31 | 0.1 | 0.0 | 0.1 | 13 | 0.9 |
| Goose Bay | 31 | 0.1 | 0.0 | 0.1 | 15 | 0.7 |
| Halifax | 31 | 0.1 | 0.0 | 0.1 | 32 | 2.2 |
| Inuvik | 31 | 0.1 | 0.0 | 0.1 | 12 | 0.3 |
| Montreal | 30 | 0.2 | 0.0 | 0.1 | 49 | 2.4 |
| Moosonee | 31 | 0.1 | 0.0 | 0.1 | 17 | 0.5 |
| Ottawa | 31 | 0.2 | 0.0 | 0.1 | 26 | 2.0 |
| Quebec | 29 | 0.1 | 0.0 | 0.1 | 35 | 2.7 |
| Regina | 31 | 0.1 | 0.0 | 0.1 | 31 | 0.7 |
| Resolute | 31 | 0.1 | 0.0 | 0.1 | NA | NA |
| St. John's, Nfld | 25 | 0.1 | 0.0 | 0.0 | 14 | 1.3 |
| Saskatoon | 31 | 0.1 | 0.0 | 0.0 | NS | NS |
| Sault Ste. Marie | 31 | 0.1 | 0.0 | 0.1 | 15 | 1.2 |
| Toronto | 31 | 0.2 | 0.0 | 0.1 | NS | NS |
| Vancouver | 31 | 0.1 | 0.0 | 0.0 | 22 | 3.9 |
| Whitehorse | 31 | 0.1 | 0.0 | 0.0 | 25 | 0.5 |
| Windsor | 31 | 0.2 | 0.0 | 0.1 | 27 | 3.2 |
| Winnipeg | 30 | 0.1 | 0.0 | 0.1 | 37 | 1.4 |
| Yellowknife | 31 | 0.1 | 0.0 | 0.1 | 46 | 0.4 |
| Network summary | — | 0.1 | 0.0 | 0.1 | 31 | 1.3 |

NA, no analysis performed
NS, no sample collected

**Table 3. Radionuclide deposition in Canadian fallout December 1965** [a]

| Station | Strontium-90 (nCi/m²) | Cesium-137 (nCi/m²) |
|---|---|---|
| Calgary | 0.02 | 0.07 |
| Coral Harbour | 0.05 | 0.08 |
| Edmonton | 0.03 | 0.09 |
| Ft. Churchill | 0.04 | 0.06 |
| Ft. William | 0.14 | 0.14 |
| Fredericton | 0.05 | 0.13 |
| Goose Bay | 0.10 | 0.10 |
| Halifax | 0.11 | 0.13 |
| Inuvik | 0.00 | 0.03 |
| Montreal | 0.21 | 0.25 |
| Moosonee | 0.03 | 0.05 |
| Ottawa | 0.15 | 0.20 |
| Quebec | 0.23 | 0.56 |
| Regina | 0.00 | 0.04 |
| Resolute | 0.05 | 0.15 |
| St. John's, Nfld | 0.13 | 0.22 |
| Saskatoon | NS | NS |
| Sault Ste. Marie | 0.13 | 0.14 |
| Toronto | NS | NS |
| Vancouver | 0.43 | 0.67 |
| Whitehorse | 0.01 | 0.01 |
| Windsor | 0.25 | 0.33 |
| Winnipeg | 0.04 | 0.06 |
| Yellowknife | 0.02 | 0.02 |
| Average | 0.10 | 0.16 |

[a] Strontium-89, zirconium-95, and barium-140 are not reported, due to insignificantly low levels.
NS, no sample collected

## 3. Pan American Air Sampling Program December 1965

*Pan American Health Organization and Public Health Service*

Gross beta activity in air is monitored by countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with these employed for the Radiation Surveillance Network. The air sampling stations are shown in figure 4.

The December 1965 air monitoring results from the participating countries are given in table 4.

**Table 4. Gross beta activity in surface air and precipitation, PAHO, December 1965**

| Station location | Number of samples | Gross beta activity, pCi/m$^3$ | | |
|---|---|---|---|---|
| | | Maximum | Minimum | Average [a] |
| Argentina: Buenos Aires | 19 | <0.10 | <0.10 | <0.10 |
| Chili: Santiago | 25 | <0.10 | <0.10 | <0.10 |
| Jamaica: Kingston | 25 | <0.10 | <0.10 | <0.10 |
| Peru: Lima | 6 | <0.10 | <0.10 | <0.10 |
| Venezuela: Caracas | 20 | 0.12 | <0.10 | <0.10 |
| West Indies: Trinidad | 6 | <0.10 | <0.10 | <0.10 |
| Pan American summary | 101 | 0.12 | <0.10 | <0.10 |

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

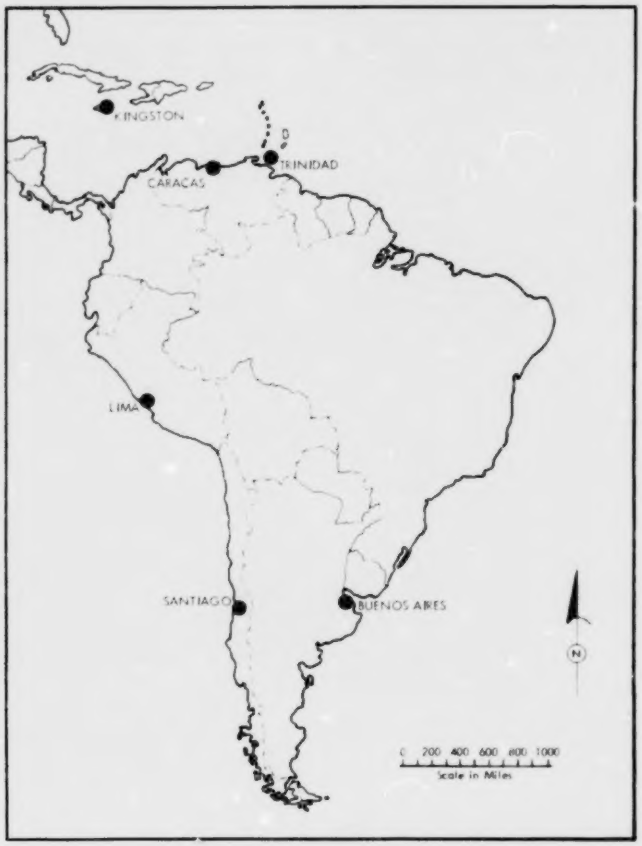

Figure 4. Pan American Air Network sampling stations

## 4. National Air Sampling Network October–December and Annual Summary, 1965

*Division of Air Pollution*
*Public Health Service*

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. One of the many analyses performed on air samples collected through the NASN is for gross beta radioactivity. NASN stations (figure 5) are manned by cooperating Federal, State, and local agencies. The network consists of 110 sampling stations which operate every year and 130 stations which operate every other year. A description of the sampling network was presented in the December 1965 issue of *Radiological Health Data*. Fourth quarter 1965 gross beta activities in air are given in table 5. Data for 1965 are summarized in table 6.

Previous coverage in *Radiological Health Data and Reports*:

| Period | Issue |
|---|---|
| Annual Summary 1964 | April 1965 |
| January–March 1965 | July 1965 |
| April–June 1965 | October 1965 |
| July–September 1965 | January 1966 |

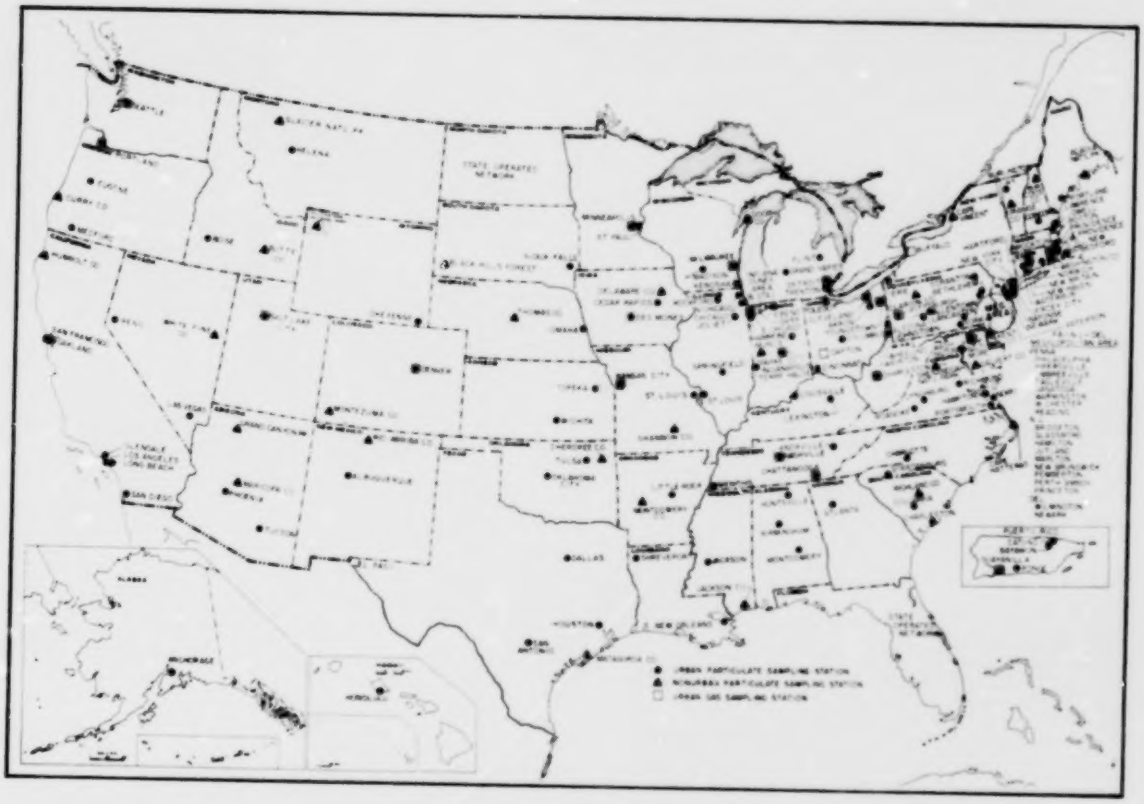
● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
□ URBAN GAS SAMPLING STATION

Figure 5. National Air Sampling Network station locations

## Table 5. Fission product gross beta activity in surface air NASN, fourth quarter 1965

(Concentrations in pCi/m³)

| | Station name | Number of samples | Maximum | Minimum | Average |
|---|---|---|---|---|---|
| Ala: | Birmingham | 5 | 0.2 | 0.1 | 0.1 |
| | Huntsville | 6 | 0.2 | 0.1 | 0.1 |
| | Montgomery | 6 | 0.2 | 0.1 | 0.1 |
| Ariz: | Grand Canyon Park* | 5 | 0.2 | 0.1 | 0.2 |
| | Paradise Valley | 6 | 0.2 | 0.1 | 0.2 |
| | Phoenix | 6 | 0.2 | 0.1 | 0.2 |
| | Tucson | 7 | 0.2 | 0.1 | 0.1 |
| Ark: | Little Rock | 6 | 0.2 | 0.1 | 0.2 |
| | Montgomery County* | 6 | 0.2 | 0.1 | 0.1 |
| Calif: | Glendale | 6 | 0.2 | 0.1 | 0.1 |
| | Humboldt County* | 5 | 0.1 | <0.1 | 0.1 |
| | Long Beach | 6 | 0.1 | 0.1 | 0.1 |
| | Los Angeles | 6 | 0.2 | 0.1 | 0.1 |
| | Oakland | 6 | 0.3 | <0.1 | 0.1 |
| | San Diego | 6 | 0.1 | 0.1 | 0.1 |
| | San Francisco | 6 | 0.2 | 0.1 | 0.1 |
| Colo: | Denver | 6 | 0.2 | 0.1 | 0.1 |
| | Montezuma County* | 5 | 0.1 | <0.1 | 0.1 |
| Conn: | Hartford | 6 | 0.1 | <0.1 | 0.1 |
| | New Britain | 6 | 0.1 | 0.1 | 0.1 |
| | New Haven | 6 | 0.2 | 0.1 | 0.1 |
| | Norwich | 6 | 0.1 | 0.1 | 0.1 |
| | Waterbury | 6 | 0.1 | 0.1 | 0.1 |
| Del: | Kent County* | 5 | 0.1 | 0.1 | 0.1 |
| | Newark | 6 | 0.2 | 0.1 | 0.1 |
| | Wilmington | 5 | 0.1 | 0.1 | 0.1 |
| D.C: | Washington | 5 | 0.1 | 0.1 | 0.1 |
| Ga: | Atlanta | 6 | 0.2 | 0.1 | 0.1 |
| Hawaii: | Honolulu | 6 | 0.1 | <0.1 | 0.1 |
| Idaho: | Boise | 6 | 0.2 | 0.1 | 0.2 |
| | Butte County* | 5 | 0.2 | 0.1 | 0.1 |
| Ill: | Chicago | 6 | 0.2 | <0.1 | 0.1 |
| | East St. Louis | 6 | 0.2 | 0.1 | 0.1 |
| | Joliet | 6 | 0.1 | 0.1 | 0.1 |
| | North Chicago | 4 | 0.2 | 0.1 | 0.2 |
| | Rockford | 6 | 0.2 | <0.1 | 0.1 |
| | Springfield | 6 | 0.1 | 0.1 | 0.1 |
| Ind: | East Chicago | 6 | 0.2 | <0.1 | 0.1 |
| | Hammond | 6 | 0.3 | <0.1 | 0.1 |
| | Indianapolis | 5 | 0.2 | 0.1 | 0.1 |
| | Parke County* | 6 | 0.2 | <0.1 | 0.1 |
| | Portage | 7 | 0.2 | <0.1 | 0.1 |
| | Beverly Shores | 5 | 0.2 | 0.1 | 0.1 |
| | Dunes Police Post #1 | 5 | 0.2 | 0.1 | 0.1 |
| | Dunes State Park | 6 | 0.1 | <0.1 | 0.1 |
| | Ogden Dunes | 6 | 0.2 | <0.1 | 0.1 |
| | South Bend | 5 | 0.1 | <0.1 | 0.1 |
| Iowa: | Cedar Rapids | 6 | 0.2 | 0.1 | 0.1 |
| | Delaware County* | 6 | 0.2 | <0.1 | 0.1 |
| | Des Moines | 6 | 0.2 | 0.1 | 0.1 |
| Kans: | Topeka | 6 | 0.2 | 0.1 | 0.1 |
| | Wichita | 6 | 0.2 | 0.1 | 0.1 |
| Ky: | Lexington | 5 | 0.2 | 0.1 | 0.2 |
| | Louisville | 6 | 0.1 | 0.1 | 0.1 |
| La: | New Orleans | 6 | 0.2 | 0.1 | 0.1 |
| | Shreveport | 6 | 0.2 | <0.1 | 0.1 |
| Maine: | Acadia Nat Park* | 5 | 0.1 | 0.1 | 0.1 |
| | Portland | 6 | 0.1 | <0.1 | 0.1 |
| Md: | Baltimore | 6 | 0.2 | 0.1 | 0.1 |
| | Calvert County* | 6 | 0.2 | 0.1 | 0.1 |
| Mass: | Brockton | 6 | 0.1 | 0.1 | 0.1 |
| | Lawrence | 4 | 0.1 | 0.1 | 0.1 |
| | Lowell | 7 | 0.2 | 0.1 | 0.1 |
| | New Bedford | 5 | 0.2 | <0.1 | 0.1 |
| Mich: | Detroit | 6 | 0.2 | <0.1 | 0.1 |
| | Flint | 6 | 0.1 | 0.1 | 0.1 |
| | Grand Rapids | 5 | 0.1 | <0.1 | 0.1 |
| | Trenton | 6 | 0.2 | 0.1 | 0.1 |
| Minn: | Minneapolis | 6 | 0.2 | <0.1 | 0.1 |
| | St Paul | 6 | 0.2 | <0.1 | 0.1 |
| Miss: | Jackson | 5 | 0.2 | 0.1 | 0.1 |
| Mo: | Jackson County* | 6 | 0.1 | 0.1 | 0.1 |
| | Kansas City | 6 | 0.2 | 0.1 | 0.2 |
| | St. Louis | 6 | 0.2 | 0.1 | 0.1 |
| | Shannon County* | 7 | 0.2 | 0.1 | 0.1 |
| Mont: | Glacier Nat Park* | 6 | 0.1 | 0.1 | 0.1 |
| | Helena | 5 | 0.2 | 0.1 | 0.1 |
| Nebr: | Omaha | 6 | 0.2 | 0.1 | 0.1 |
| | Thomas County* | 6 | 0.2 | 0.1 | 0.2 |
| Nev: | Las Vegas | 6 | 0.3 | 0.1 | 0.2 |
| | Reno | 5 | 0.2 | 0.1 | 0.2 |
| | White Pine County* | 6 | 0.1 | 0.1 | 0.1 |
| N.H: | Concord | 5 | 0.1 | 0.1 | 0.1 |
| | Coos County* | 6 | 0.2 | <0.1 | 0.1 |
| N.J: | Bayonne | 3 | 0.2 | 0.1 | 0.1 |
| | Bridgeton | 6 | 0.2 | 0.1 | 0.1 |
| | Pemberton | 6 | 0.2 | <0.1 | 0.1 |
| | Marion | 6 | 0.2 | 0.1 | 0.1 |
| N.J.—Continued | | | | | |
| | Glassboro | 6 | 0.1 | 0.1 | 0.1 |
| | Hamilton | 6 | 0.2 | 0.1 | 0.1 |
| | Jutland | 7 | 0.1 | <0.1 | 0.1 |
| | Jersey City | 6 | 0.2 | <0.1 | 0.1 |
| | Newark | 5 | 0.1 | 0.1 | 0.1 |
| | New Brunswick | 4 | 0.1 | 0.1 | 0.1 |
| | Paterson | 5 | 0.2 | 0.1 | 0.1 |
| | Perth Amboy | 5 | 0.2 | 0.1 | 0.1 |
| | Princeton | 4 | 0.2 | 0.1 | 0.1 |
| N.Mex: | Albuquerque | 6 | 0.2 | <0.1 | 0.1 |
| | Rio Arriba County* | 6 | 0.1 | 0.1 | 0.1 |
| N.Y: | Cape Vincent* | 6 | 0.1 | 0.1 | 0.1 |
| | New York City | 6 | 0.1 | <0.1 | 0.1 |
| N.C: | Charlotte | 6 | 0.2 | 0.1 | 0.1 |
| | Cape Hatteras* | 6 | 0.2 | 0.1 | 0.1 |
| Ohio: | Akron | 6 | 0.2 | 0.1 | 0.1 |
| | Cincinnati | 6 | 0.2 | 0.1 | 0.2 |
| | Cleveland | 6 | 0.2 | <0.1 | 0.1 |
| | Columbus | 6 | 0.2 | 0.1 | 0.1 |
| | Toledo | 5 | 0.2 | 0.1 | 0.1 |
| | Youngstown | 6 | 0.2 | 0.1 | 0.1 |
| Okla: | Cherokee County* | 6 | 0.2 | 0.1 | 0.2 |
| | Oklahoma City | 6 | 0.2 | 0.1 | 0.2 |
| | Tulsa | 6 | 0.2 | <0.1 | 0.1 |
| Ore: | Curry County* | 6 | 0.1 | <0.1 | <0.1 |
| | Eugene | 6 | 0.2 | <0.1 | 0.1 |
| | Medford | 5 | 0.1 | <0.1 | 0.1 |
| | Portland | 5 | 0.2 | <0.1 | 0.1 |
| Pa: | Allentown | 6 | 0.1 | 0.1 | 0.1 |
| | Altoona | 5 | 0.1 | 0.1 | 0.1 |
| | Bethlehem | 6 | 0.2 | 0.1 | 0.1 |
| | Pipersville | 6 | 0.1 | 0.1 | 0.1 |
| | Embreeville | 6 | 0.1 | 0.1 | 0.1 |
| | Clarion County* | 6 | 0.1 | <0.1 | 0.1 |
| | Erie | 5 | 0.1 | <0.1 | 0.1 |
| | Johnstown | 6 | 0.2 | 0.1 | 0.1 |
| | Lancaster | 6 | 0.2 | 0.1 | 0.1 |
| | Eagleville | 4 | 0.1 | 0.1 | 0.1 |
| | Sanatoga | 5 | 0.2 | <0.1 | 0.1 |
| | Philadelphia | 6 | 0.2 | 0.1 | 0.1 |
| | Pittsburgh | 6 | 0.2 | 0.1 | 0.1 |
| | Reading | 6 | 0.2 | 0.1 | 0.1 |
| | Warminster | 6 | 0.1 | <0.1 | 0.1 |
| | West Chester | 5 | 0.1 | <0.1 | 0.1 |
| | York | 6 | 0.1 | 0.1 | 0.1 |
| P.R: | Bayamón | 6 | 0.1 | <0.1 | 0.1 |
| | Guayanilla | 5 | 0.1 | <0.1 | <0.1 |
| | Ponce | 6 | 0.1 | <0.1 | 0.1 |
| | San Juan | 5 | 0.1 | <0.1 | 0.1 |
| R.I: | East Providence | 6 | 0.1 | <0.1 | 0.1 |
| | Providence | 6 | 0.2 | 0.1 | 0.1 |
| | Washington County* | 6 | 0.2 | 0.1 | 0.1 |
| S.C: | Charleston | 7 | 0.2 | 0.1 | 0.1 |
| | Columbia | 5 | 0.2 | 0.1 | 0.1 |
| | Richland County* | 6 | 0.2 | 0.1 | 0.1 |
| | Spartanburg | 6 | 0.2 | 0.1 | 0.2 |
| S.Dak: | Black Hills Forest* | 6 | 0.2 | 0.1 | 0.1 |
| | Sioux Falls | 6 | 0.2 | 0.1 | 0.1 |
| Tenn: | Chattanooga | 6 | 0.2 | 0.1 | 0.2 |
| | Knoxville | 6 | 0.1 | <0.1 | 0.1 |
| | Memphis | 7 | 0.3 | 0.1 | 0.1 |
| | Nashville | 5 | 0.2 | <0.1 | 0.1 |
| Tex: | Dallas | 6 | 0.3 | <0.1 | 0.2 |
| | Houston | 6 | 0.2 | <0.1 | 0.1 |
| | Matagorda County* | 6 | 0.1 | <0.1 | 0.1 |
| | San Antonio | 5 | 0.2 | 0.1 | 0.1 |
| Utah: | Salt Lake City | 6 | 0.2 | 0.1 | 0.2 |
| Vt: | Burlington | 6 | 0.1 | <0.1 | 0.1 |
| | Orange County* | 6 | 0.1 | 0.1 | 0.1 |
| Va: | Hampton | 6 | 0.2 | 0.1 | 0.1 |
| | Lynchburg | 5 | 0.2 | 0.1 | 0.1 |
| | Norfolk | 6 | 0.1 | 0.1 | 0.1 |
| | Shenandoah Nat Park* | 5 | 0.1 | 0.1 | 0.1 |
| | Portsmouth | 6 | 0.1 | <0.1 | 0.1 |
| | Richmond | 6 | 0.2 | 0.1 | 0.1 |
| | Roanoke | 5 | 0.1 | 0.1 | 0.1 |
| Wash: | Seattle | 5 | 0.1 | <0.1 | 0.1 |
| W. Va: | Charleston | 6 | 0.2 | 0.1 | 0.1 |
| | Weirton | 5 | 0.1 | 0.1 | 0.1 |
| | Wheeling | 5 | 0.2 | 0.1 | 0.1 |
| Wis: | Door County* | 6 | 0.2 | <0.1 | 0.1 |
| | Kenosha | 6 | 0.2 | 0.1 | 0.1 |
| | Madison | 6 | 0.2 | <0.1 | 0.1 |
| | Milwaukee | 6 | 0.2 | <0.1 | 0.1 |
| Wyo: | Cheyenne | 6 | 0.2 | <0.1 | 0.1 |
| | Yellowstone Park* | 5 | 0.1 | 0.1 | 0.1 |

* Denotes nonurban station.

### Table 6. Fission product gross beta activity in surface air, NASN, annual summary 1965

(Concentrations in $\mu$Ci/m$^3$)

| | Station name | Number of samples | Maximum | Minimum | Average |
|---|---|---|---|---|---|
| Ala: | Birmingham | 24 | 1.1 | 0.1 | 0.3 |
| | Huntsville | 26 | 1.1 | <0.1 | 0.4 |
| | Montgomery | 25 | 1.1 | 0.1 | 0.3 |
| Ariz: | Grand Canyon Park* | 24 | 1.3 | 0.1 | 0.4 |
| | Paradise Valley | 26 | 2.0 | 0.1 | 0.6 |
| | Phoenix | 26 | 1.7 | <0.1 | 0.5 |
| | Tucson | 25 | 8.8 | 0.1 | 0.7 |
| Ark: | Little Rock | 23 | 1.4 | 0.1 | 0.3 |
| | Montgomery County* | 21 | 0.7 | 0.1 | 0.3 |
| Calif: | Glendale | 26 | 1.2 | 0.1 | 0.4 |
| | Humboldt County* | 24 | 0.6 | <0.1 | 0.2 |
| | Long Beach | 25 | 1.4 | 0.1 | 0.4 |
| | Los Angeles | 23 | 1.2 | 0.1 | 0.4 |
| | Oakland | 24 | 0.7 | <0.1 | 0.2 |
| | San Diego | 25 | 0.8 | 0.1 | 0.3 |
| | San Francisco | 26 | 0.7 | 0.1 | 0.2 |
| Colo: | Denver | 24 | 1.6 | 0.1 | 0.4 |
| | Montezuma County* | 23 | 1.4 | <0.1 | 0.5 |
| Conn: | Hartford | 26 | 1.2 | <0.1 | 0.4 |
| | New Britain | 26 | 1.2 | 0.1 | 0.4 |
| | New Haven | 24 | 1.2 | <0.1 | 0.3 |
| | Norwich | 24 | 1.2 | 0.1 | 0.4 |
| | Waterbury | 26 | 1.3 | 0.1 | 0.4 |
| Del: | Kent County* | 23 | 1.0 | 0.1 | 0.3 |
| | Newark | 24 | 1.3 | <0.1 | 0.3 |
| | Wilmington | 23 | 1.1 | 0.1 | 0.3 |
| D.C: | Washington | 24 | 1.3 | 0.1 | 0.3 |
| Ga: | Atlanta | 24 | 0.9 | <0.1 | 0.3 |
| Hawaii: | Honolulu | 26 | 3.0 | <0.1 | 0.4 |
| Idaho: | Boise | 25 | 1.2 | 0.1 | 0.4 |
| | Butte County* | 23 | 1.4 | <0.1 | 0.4 |
| Ill: | Chicago | 24 | 0.8 | <0.1 | 0.3 |
| | East St. Louis | 25 | 1.5 | 0.1 | 0.4 |
| | Joliet | 23 | 0.6 | 0.1 | 0.3 |
| | North Chicago | 21 | 0.9 | 0.1 | 0.3 |
| | Rockford | 26 | 0.9 | <0.1 | 0.3 |
| | Springfield | 25 | 0.7 | 0.1 | 0.3 |
| Ind: | East Chicago | 25 | 0.8 | <0.1 | 0.3 |
| | Hammond | 25 | 0.9 | <0.1 | 0.3 |
| | Indianapolis | 25 | 1.2 | 0.1 | 0.3 |
| | Parke County* | 25 | 1.1 | <0.1 | 0.3 |
| | Portage | 23 | 1.1 | <0.1 | 0.3 |
| | Beverly Shores | 25 | 0.8 | 0.1 | 0.3 |
| | Dunes Police Post #1 | 23 | 1.0 | 0.1 | 0.3 |
| | Dunes State Park | 23 | 1.0 | <0.1 | 0.2 |
| | Ogden Dunes | 24 | 0.6 | <0.1 | 0.2 |
| | South Bend | 23 | 1.8 | <0.1 | 0.4 |
| Iowa: | Cedar Rapids | 26 | 0.8 | 0.1 | 0.3 |
| | Delaware County* | 25 | 0.6 | <0.1 | 0.2 |
| | Des Moines | 25 | 1.1 | 0.1 | 0.3 |
| Kans: | Topeka | 25 | 1.6 | 0.1 | 0.3 |
| | Wichita | 26 | 1.0 | 0.1 | 0.3 |
| Ky: | Lexington | 24 | 1.4 | 0.1 | 0.4 |
| | Louisville | 23 | 0.6 | 0.1 | 0.3 |
| La: | New Orleans | 25 | 1.3 | <0.1 | 0.3 |
| | Shreveport | 26 | 1.3 | <0.1 | 0.3 |
| Maine: | Acadia Nat Park* | 22 | 0.7 | 0.1 | 0.3 |
| | Portland | 23 | 1.3 | <0.1 | 0.3 |
| Md: | Baltimore | 26 | 2.4 | <0.1 | 0.4 |
| | Calvert County* | 26 | 0.8 | 0.1 | 0.3 |
| Mass: | Brockton | 24 | 1.2 | 0.1 | 0.3 |
| | Lawrence | 23 | 2.0 | 0.1 | 0.4 |
| | Lowell | 23 | 2.0 | 0.1 | 0.4 |
| | New Bedford | 20 | 1.5 | <0.1 | 0.5 |
| Mich: | Detroit | 24 | 1.5 | <0.1 | 0.4 |
| | Flint | 25 | 1.3 | <0.1 | 0.3 |
| | Grand Rapids | 23 | 0.8 | <0.1 | 0.3 |
| | Trenton | 25 | 1.3 | 0.1 | 0.4 |
| Minn: | Minneapolis | 26 | 0.8 | <0.1 | 0.3 |
| | St Paul | 26 | 0.8 | <0.1 | 0.3 |
| Miss: | Jackson | 24 | 1.6 | 0.1 | 0.4 |
| | Jackson County* | 25 | 1.4 | <0.1 | 0.3 |
| Mo: | Kansas City | 24 | 0.7 | 0.1 | 0.3 |
| | St Louis | 25 | 1.2 | 0.1 | 0.3 |
| | Shannon County* | 26 | 0.9 | 0.1 | 0.3 |
| Mont: | Glacier Nat Park* | 23 | 1.0 | 0.1 | 0.3 |
| | Helena | 22 | 1.4 | <0.1 | 0.4 |
| Nebr: | Omaha | 25 | 0.8 | 0.1 | 0.3 |
| | Thomas County* | 26 | 0.9 | <0.1 | 0.3 |
| Nev: | Las Vegas | 26 | 1.9 | 0.1 | 0.6 |
| | Reno | 25 | 1.4 | 0.1 | 0.5 |
| | White Pine County* | 23 | 1.4 | 0.1 | 0.4 |
| N.H: | Concord | 25 | 1.0 | 0.1 | 0.4 |
| | Coos County* | 23 | 0.9 | <0.1 | 0.3 |
| N.J: | Bayonne | 19 | 1.8 | 0.1 | 0.5 |
| | Bridgeton | 24 | 0.8 | <0.1 | 0.3 |
| | Pemberton | 26 | 1.0 | <0.1 | 0.3 |
| N.J.—Continued | | | | | |
| | Marlton | 23 | 1.3 | <0.1 | 0.3 |
| | Glassboro | 24 | 1.1 | <0.1 | 0.3 |
| | Hamilton | 24 | 1.4 | <0.1 | 0.3 |
| | Jutland | 23 | 1.1 | <0.1 | 0.3 |
| | Jersey City | 26 | 1.3 | <0.1 | 0.3 |
| | Newark | 24 | 2.0 | <0.1 | 0.4 |
| | New Brunswick | 22 | 0.9 | 0.1 | 0.3 |
| | Paterson | 24 | 1.8 | <0.1 | 0.4 |
| | Perth Amboy | 24 | 1.6 | <0.1 | 0.4 |
| | Princeton | 21 | 0.7 | 0.1 | 0.3 |
| N.Mex: | Albuquerque | 25 | 1.6 | <0.1 | 0.4 |
| | Rio Arriba County* | 25 | 2.6 | <0.1 | 0.5 |
| N.Y: | Cape Vincent* | 25 | 1.2 | 0.1 | 0.4 |
| | New York City | 24 | 1.2 | <0.1 | 0.3 |
| N.C: | Charlotte | 26 | 1.2 | 0.1 | 0.3 |
| | Cape Hatteras* | 26 | 0.8 | 0.1 | 0.3 |
| Ohio: | Akron | 25 | 1.3 | 0.1 | 0.4 |
| | Cincinnati | 25 | 1.2 | 0.1 | 0.4 |
| | Cleveland | 26 | 3.6 | <0.1 | 0.5 |
| | Columbus | 25 | 1.4 | 0.1 | 0.4 |
| | Toledo | 26 | 1.5 | <0.1 | 0.4 |
| | Youngstown | 26 | 1.3 | <0.1 | 0.4 |
| Okla: | Cherokee County* | 25 | 1.3 | 0.1 | 0.4 |
| | Oklahoma City | 26 | 0.9 | 0.1 | 0.3 |
| | Tulsa | 25 | 0.8 | <0.1 | 0.3 |
| Ore: | Curry County* | 24 | 0.5 | <0.1 | 0.2 |
| | Eugene | 26 | 0.5 | <0.1 | 0.2 |
| | Medford | 24 | 0.9 | <0.1 | 0.3 |
| | Portland | 25 | 0.8 | <0.1 | 0.3 |
| Pa: | Allentown | 22 | 1.7 | 0.1 | 0.3 |
| | Altoona | 21 | 1.4 | 0.1 | 0.5 |
| | Bethlehem | 24 | 2.0 | <0.1 | 0.4 |
| | Pipersville | 23 | 1.7 | 0.1 | 0.3 |
| | Embreeville | 24 | 1.0 | 0.1 | 0.3 |
| | Clarion County* | 25 | 1.8 | <0.1 | 0.3 |
| | Erie | 24 | 1.6 | <0.1 | 0.4 |
| | Johnstown | 24 | 0.8 | 0.1 | 0.3 |
| | Lancaster | 25 | 1.1 | <0.1 | 0.4 |
| | Eagleville | 21 | 1.2 | 0.1 | 0.3 |
| | Sanatoga | 22 | 1.8 | <0.1 | 0.3 |
| | Philadelphia | 25 | 1.1 | <0.1 | 0.3 |
| | Pittsburgh | 24 | 1.2 | <0.1 | 0.3 |
| | Reading | 24 | 2.1 | <0.1 | 0.4 |
| | Warminster | 24 | 2.9 | <0.1 | 0.4 |
| | West Chester | 24 | 0.8 | <0.1 | 0.3 |
| | York | 26 | 1.4 | <0.1 | 0.4 |
| P.R: | Bayamón | 23 | 2.0 | <0.1 | 0.3 |
| | Guayanilla | 20 | 0.7 | <0.1 | 0.2 |
| | Ponce | 21 | 1.1 | <0.1 | 0.2 |
| | San Juan | 24 | 0.9 | <0.1 | 0.2 |
| R.I: | East Providence | 24 | 0.8 | <0.1 | 0.2 |
| | Providence | 26 | 2.0 | 0.1 | 0.4 |
| | Washington County* | 26 | 1.4 | 0.1 | 0.4 |
| S.C: | Charleston | 25 | 1.1 | 0.1 | 0.3 |
| | Richland County* | 20 | 0.8 | <0.1 | 0.3 |
| | Spartanburg | 26 | 1.4 | 0.1 | 0.4 |
| S Dak: | Black Hills Forest* | 26 | 0.9 | <0.1 | 0.3 |
| | Sioux Falls | 26 | 0.8 | <0.1 | 0.3 |
| Tenn: | Chattanooga | 24 | 1.2 | <0.1 | 0.4 |
| | Knoxville | 25 | 1.2 | <0.1 | 0.3 |
| | Memphis | 26 | 1.1 | <0.1 | 0.3 |
| | Nashville | 23 | 1.0 | 0.1 | 0.3 |
| Tex: | Dallas | 26 | 1.8 | <0.1 | 0.4 |
| | Houston | 25 | 1.0 | <0.1 | 0.3 |
| | Matagorda County* | 25 | 1.0 | <0.1 | 0.3 |
| | San Antonio | 25 | 0.6 | <0.1 | 0.3 |
| Utah: | Salt Lake City | 26 | 2.5 | 0.1 | 0.5 |
| Vt: | Burlington | 25 | 1.2 | <0.1 | 0.3 |
| | Orange County* | 24 | 1.4 | 0.1 | 0.4 |
| Va: | Hampton | 25 | 1.3 | 0.1 | 0.3 |
| | Lynchburg | 25 | 1.2 | 0.1 | 0.4 |
| | Norfolk | 25 | 1.5 | 0.1 | 0.4 |
| | Shenandoah Nat Park* | 25 | 1.2 | <0.1 | 0.4 |
| | Portsmouth | 26 | 0.8 | <0.1 | 0.3 |
| | Richmond | 25 | 1.5 | <0.1 | 0.5 |
| | Roanoke | 24 | 1.0 | <0.1 | 0.4 |
| Wash: | Seattle | 26 | 0.8 | <0.1 | 0.2 |
| W. Va: | Charleston | 25 | 0.8 | 0.1 | 0.3 |
| | Weirton | 23 | 1.2 | 0.1 | 0.4 |
| | Wheeling | 25 | 1.3 | <0.1 | 0.4 |
| Wis: | Door County* | 21 | 0.8 | <0.1 | 0.3 |
| | Kenosha | 25 | 2.0 | 0.1 | 0.4 |
| | Madison | 25 | 1.0 | <0.1 | 0.3 |
| | Milwaukee | 25 | 0.8 | <0.1 | 0.3 |
| Wyo: | Cheyenne | 25 | 1.4 | <0.1 | 0.4 |
| | Yellowstone Park* | 24 | 1.1 | <0.1 | 0.4 |

*Denotes nonurban station.

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38

# Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

## STRONTIUM-90 IN HUMAN BONE, DEATHS THROUGH 1964

*Division of Radiological Health, Public Health Service*

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium–90 in measurable amounts has been present in the global environment for more than a decade, and major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium–90 content to be low and age-independent (*1*).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for comparison to British data have not been successful.

The results of laboratory analyses for strontium–90 in individual bones from persons dying through 1964 which have not previously been published in *Radiological Health Data & Reports* are presented in table 1. All data are summarized in table 2.

The data are reported as picocuries of strontium–90 per gram of ash (the primary determination), per gram of calcium (for comparison with other data and for purposes of model development) and per gram of bone (as a rough indication of dose). Two–sigma counting errors are reported for the ash concentration. Following the pattern of earlier reports (*2–4*) subsequent articles will provide interpretation of the data at appropriate stages in the program.

### Table 1. Details of samples and results of analyses

| Region, state, and sample number | Age at death [a] | | | Sex | Date of death | | | Bone type [b] | Original weight (g) | Ash weight (g) | pCi strontium-90/g of: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yrs | Mo | Day | | Yr | Mo | Day | | | | Ash ±2s.d. C.E. | Calcium | Bone |
| Northeast | | | | | | | | | | | | | |
| Maine | | | | | | | | | | | | | |
| I-9(0003) | 16 | 3 | 29 | M | 64 | 3 | 15 | S | 277.3 | 7.7 | 0.80 ±0.12 | 2.49 | 0.02 |
| Massachusetts | | | | | | | | | | | | | |
| I-2(0065) | 12 | 5 | 9 | M | 64 | 1 | 11 | V | 207.7 | 24.3 | 0.69 ±0.01 | 1.88 | 0.08 |
| I-2(0074) | 13 | 4 | 23 | M | 64 | 2 | 2 | V | 86.7 | 7.3 | 0.87 ±0.13 | 2.41 | 0.07 |
| I-2(0096) | 5 | 11 | 8 | F | 64 | 4 | 9 | V | 106.3 | 9.1 | 1.00 ±0.11 | 2.85 | 0.09 |
| I-2(0098) | 20 | 8 | 18 | M | 64 | 4 | 14 | V | 125.1 | 17.2 | 0.96 ±0.08 | 2.66 | 0.13 |
| I-2(0098) [c] | 20 | 8 | 18 | M | 64 | 4 | 14 | V | 125.1 | 17.2 | 0.43 ±0.06 | 1.18 | 0.06 |
| I-2(0103) | 9 | | 13 | F | 64 | 5 | 10 | V | 164.4 | 12.8 | 1.07 ±0.10 | 3.11 | 0.08 |
| I-2(0106) | 12 | 3 | | F | 64 | 5 | 21 | V | 116.9 | 8.8 | 0.75 ±0.11 | 2.13 | 0.06 |
| I-2(0113) | 13 | | | M | 64 | 6 | 2 | V | 119.3 | 19.8 | 1.10 ±0.07 | 2.97 | 0.18 |
| I-2(0114) | 8 | 11 | | M | 64 | 6 | 6 | V | 83.7 | 6.0 | 0.39 ±0.10 | 1.15 | 0.03 |
| I-2(0115) | 15 | 11 | 1 | M | 64 | 6 | 23 | V | 97.1 | 12.0 | 0.69 ±0.08 | 1.83 | 0.09 |
| I-2(0117) [c] | 12 | | | M | 64 | 6 | 27 | V | 139.6 | 13.5 | 0.54 ±0.08 | 1.50 | 0.05 |
| I-2(0117) | 12 | | | M | 64 | 6 | 27 | V | 139.6 | 13.5 | 1.14 ±0.10 | 3.08 | 0.11 |
| I-2(0121) | 14 | | | M | 64 | 8 | 2 | V | 199.0 | 22.9 | 1.08 ±0.06 | 2.92 | 0.13 |
| I-2(0124) | 10 | | | M | 64 | 8 | 27 | V | 85.2 | 9.1 | 1.10 ±0.13 | 3.04 | 0.12 |
| I-2(0132) | 7 | 11 | 19 | F | 64 | 9 | 26 | V | 109.4 | 11.0 | 0.91 ±0.03 | 2.48 | 0.09 |
| I-2(0138) | 3 | 11 | 6 | F | 64 | 11 | 13 | V | 87.5 | 7.3 | 1.55 ±0.16 | 4.48 | 0.13 |
| I-2(0139) | 2 | 7 | 22 | M | 64 | 11 | 16 | V | 67.5 | 5.6 | 1.83 ±0.24 | 5.39 | 0.15 |
| I-2(0140) | 6 | 10 | 17 | F | 64 | 12 | 8 | V | 85.2 | 9.7 | 1.90 ±0.15 | 5.19 | 0.22 |
| I-2(0108) | 2 | 10 | 6 | M | 64 | 5 | 24 | V | 105.6 | 7.4 | 2.25 ±0.18 | 6.42 | 0.16 |
| I-2(0109) | 8 | | | F | 64 | 5 | 27 | V | 220.4 | 16.9 | 0.89 ±0.08 | 2.49 | 0.07 |
| I-2(0110) | 5 | 6 | 6 | F | 64 | 5 | 29 | V | 138.0 | 10.6 | 1.42 ±0.12 | 3.96 | 0.11 |
| I-7(0006) | 21 | 5 | 3 | M | 64 | 12 | 12 | V | 89.5 | 14.5 | 0.81 ±0.08 | 2.12 | 0.13 |
| I-7(0006) [c] | 21 | 5 | 3 | M | 64 | 12 | 12 | V | 89.5 | 14.5 | 0.75 ±0.08 | 1.98 | 0.12 |
| I-8(0026) | 25 | 3 | 20 | F | 64 | 11 | 27 | V | 76.6 | 7.5 | 1.13 ±0.13 | 2.99 | 0.11 |
| I-8(0027) | 24 | | | M | 64 | 12 | 21 | V | 86.1 | 10.6 | 0.44 ±0.07 | 1.22 | 0.06 |
| I-15(0001) | 22 | 4 | 24 | M | 64 | 10 | 4 | V | 125.0 | 17.0 | 0.64 ±0.06 | 1.68 | 0.09 |
| New Jersey | | | | | | | | | | | | | |
| II-36(0005) | 8 | 7 | 18 | M | 64 | 5 | 9 | V | 165.2 | 19.3 | 1.10 ±0.08 | 3.11 | 0.13 |
| New York | | | | | | | | | | | | | |
| II-10(0009) | 19 | 1 | 12 | M | 63 | 5 | 5 | V | 169.5 | 19.8 | 0.60 ±0.07 | 1.65 | 0.07 |
| II-10(0011) | 14 | 2 | 25 | F | 63 | 5 | 27 | V | 156.5 | 18.1 | 0.57 ±0.07 | 1.54 | 0.07 |
| II-10(0012) | 24 | 2 | 14 | M | 63 | 6 | 10 | V | 168.6 | 17.8 | 0.65 ±0.08 | 1.73 | 0.07 |
| II-10(0013) | 23 | 1 | 24 | M | 63 | 7 | 28 | V | 94.3 | 14.0 | 1.01 ±0.11 | 2.70 | 0.15 |
| II-10(0014) | 17 | 11 | 24 | F | 63 | 7 | 28 | V | 177.6 | 21.2 | 0.80 ±0.08 | 2.14 | 0.10 |
| II-10(0015) | 15 | 1 | 12 | M | 63 | 7 | 28 | V | 163.5 | 19.7 | 0.83 ±0.08 | 2.28 | 0.10 |
| II-10(0016) | 18 | 5 | 27 | M | 63 | 8 | 14 | V | 151.8 | 22.1 | 0.78 ±0.08 | 2.07 | 0.11 |
| II-10(0017) | 17 | 5 | 29 | M | 63 | 8 | 14 | V | 143.0 | 22.2 | 1.00 ±0.09 | 2.59 | 0.16 |
| II-10(0019) | 22 | 9 | 21 | M | 63 | 11 | 17 | V | 179.6 | 24.0 | 0.91 ±0.08 | 2.38 | 0.12 |
| II-10(0020) | 19 | 5 | 10 | M | 63 | 11 | 20 | V | 166.3 | 12.4 | 0.90 ±0.12 | 2.44 | 0.07 |
| II-10(0023) | 25 | 3 | 9 | M | 64 | 3 | 3 | V | 149.8 | 19.9 | 0.43 ±0.05 | 1.15 | 0.06 |
| II-10(0024) | 24 | 1 | 13 | M | 64 | 3 | 11 | V | 139.8 | 17.7 | 0.77 ±0.07 | 2.07 | 0.10 |
| II-12(0015) | 23 | 7 | 7 | M | 64 | 2 | 24 | V | 180.9 | 20.2 | 0.46 ±0.05 | 1.28 | 0.05 |
| II-12(0016) | 19 | 3 | 7 | M | 64 | 3 | 3 | V | 171.0 | 18.0 | 0.71 ±0.07 | 1.88 | 0.08 |
| II-23(0003) | 21 | 2 | 15 | M | 64 | 4 | 19 | V | 113.6 | 13.2 | 0.68 ±0.07 | 1.83 | 0.04 |
| II-23(0003) | 21 | 2 | 15 | M | 64 | 4 | 19 | V | 113.6 | 13.2 | 0.59 ±0.07 | 1.55 | 0.07 |
| II-23(0005) | 17 | 7 | 3 | M | 64 | 6 | 24 | V | 219.8 | 20.9 | 0.86 ±0.06 | 2.41 | 0.08 |
| II-23(0006) | 18 | 11 | | M | 64 | 7 | 19 | V | 167.2 | 21.8 | 0.65 ±0.05 | 1.70 | 0.09 |
| II-23(0008) | 19 | 6 | 20 | M | 64 | 7 | 25 | V | 148.2 | 19.8 | 0.60 ±0.06 | 1.61 | 0.08 |
| II-23(0009) | 18 | 3 | 22 | F | 64 | 8 | 16 | V | 136.8 | 21.4 | 0.85 ±0.06 | 2.24 | 0.13 |
| II-23(0010) | 18 | 2 | 24 | M | 64 | 8 | 28 | V | 106.9 | 14.8 | 0.87 ±0.08 | 2.32 | 0.06 |
| II-23(0010) | 18 | 2 | 24 | M | 64 | 8 | 28 | V | 106.9 | 14.7 | 0.79 ±0.07 | 2.20 | 0.11 |
| II-23(0011) | 15 | 2 | 26 | M | 64 | 9 | 13 | V | 213.0 | 22.5 | 0.98 ±0.07 | 2.71 | 0.10 |
| II-23(0012) | 17 | 4 | 17 | M | 64 | 9 | 24 | V | 117.9 | 15.9 | 1.18 ±0.09 | 3.12 | 0.16 |
| II-23(0013) | 5 | 8 | 26 | M | 64 | 10 | 11 | V | 104.5 | 9.1 | 0.97 ±0.11 | 2.78 | 0.08 |
| II-23(0016) | 17 | | 2 | M | 64 | 11 | 26 | V | 97.9 | 14.4 | 1.11 ±0.09 | 2.92 | 0.16 |
| II-23(0017) | 23 | 6 | | M | 64 | 12 | 15 | V | 123.7 | 16.3 | 0.79 ±0.07 | 2.12 | 0.10 |
| II-23(0018) | 23 | 1 | 11 | F | 64 | 12 | 17 | V | 159.5 | 23.3 | 0.51 ±0.05 | 1.37 | 0.08 |
| II-31(0001) | 16 | 10 | 4 | M | 64 | 9 | 7 | V | 164.8 | 17.8 | 0.96 ±0.08 | 2.58 | 0.10 |
| II-38(0006) | 15 | 7 | 7 | M | 64 | 2 | 25 | V | 110.4 | 13.7 | 1.31 ±0.10 | 3.50 | 0.16 |
| II-38(0006) | 15 | 7 | 7 | M | 64 | 2 | 25 | V | 110.4 | 13.7 | 1.10 ±0.09 | 3.01 | 0.14 |
| II-38(0007) | 8 | 3 | 10 | M | 64 | 3 | 1 | V | 162.0 | 14.4 | 0.83 ±0.08 | 2.36 | 0.07 |
| II-38(0008) | 7 | 1 | 3 | F | 64 | 3 | 3 | V | 143.6 | 16.0 | 0.93 ±0.08 | 2.46 | 0.10 |
| II-38(0009) | 9 | 4 | 22 | F | 64 | 3 | 10 | V | 190.1 | 17.5 | 0.83 ±0.07 | 2.31 | 0.08 |
| II-38(0013) | 5 | 3 | 1 | M | 64 | 4 | 1 | V | 158.1 | 12.0 | 1.00 ±0.09 | 2.83 | 0.08 |
| II-38(0014) | 16 | 10 | 21 | M | 64 | 4 | 20 | V | 79.7 | 13.9 | 0.69 ±0.07 | 1.[illegible] | 0.12 |
| II-38(0016) | 8 | 7 | 3 | F | 64 | 4 | 29 | V | 147.8 | 14.6 | 0.75 ±0.07 | 2.03 | 0.07 |
| II-38(0017) | 4 | 8 | 14 | F | 64 | 5 | 4 | V | 152.2 | 10.3 | 1.07 ±0.15 | 3.23 | 0.07 |
| II-38(0018) | 21 | 7 | 17 | F | 64 | 5 | 5 | V | 166.1 | 17.5 | 0.29 ±0.04 | 0.76 | 0.03 |
| II-38(0019) | 15 | 8 | 7 | F | 64 | 5 | 6 | V | 183.0 | 25.1 | 0.46 ±0.04 | 1.25 | 0.06 |
| II-38(0020) | 13 | 5 | 27 | M | 64 | 5 | 13 | V | 160.7 | 12.6 | 0.79 ±0.08 | 2.13 | 0.06 |
| II-38(0024) | 23 | 4 | 17 | F | 64 | 6 | 16 | V | 159.6 | 21.5 | 0.42 ±0.04 | 1.12 | 0.06 |
| II-38(0025) | 4 | | 5 | M | 64 | 6 | 28 | V | 137.0 | 13.7 | 1.47 ±0.11 | 4.02 | 0.15 |

## Table 1—Continued

| Region, state, and sample number | Age at death [a] | | | Sex | Date of death | | | Bone type [b] | Original weight (g) | Ash weight (g) | pCi strontium-90/g of: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yrs | Mo | Day | | Yr | Mo | Day | | | | Ash ±2s.d. C.E. | Calcium | Bone |
| New York—Continued | | | | | | | | | | | | | |
| II-38(0026) | 4 | 6 | 20 | F | 64 | 7 | 7 | V | 141.7 | 11.4 | 0.94 ±0.03 | 2.55 | 0.08 |
| II-38(0027) | 18 | | 14 | F | 64 | 7 | 17 | V | 163.1 | 24.8 | 0.83 ±0.06 | 2.19 | 0.13 |
| II-38(0028) | 22 | | 12 | F | 64 | 7 | 21 | V | 167.9 | [illegible] | 0.81 ±0.07 | 2.21 | 0.08 |
| II-38(0029) | 23 | 7 | 29 | F | 64 | 7 | 23 | V | 172.6 | [illegible] | 0.46 ±0.06 | 1.26 | 0.04 |
| II-38(0030) | 3 | 1 | 15 | F | 64 | 7 | 26 | V | 112.3 | [illegible] | 1.71 ±0.13 | 4.60 | 0.14 |
| II-38(0031) | 4 | 9 | 2 | M | 64 | 7 | 29 | V | 147.8 | 14.7 | 1.59 ±0.10 | 4.34 | 0.16 |
| II-38(0032) | 7 | 6 | 21 | M | 64 | 8 | 22 | V | 168.8 | 17.3 | 0.92 ±0.07 | 2.68 | 0.09 |
| II-38(0033) | 13 | | 24 | F | 64 | 8 | 28 | V | 162.7 | 21.8 | 1.14 ±0.07 | 3.01 | 0.15 |
| II-38(0035) | 10 | 4 | 15 | M | 64 | 9 | 17 | V | 140.8 | 12.2 | 1.29 ±0.12 | 3.63 | 0.11 |
| II-38(0037) | 24 | 11 | 6 | F | 64 | 10 | 27 | V | 165.9 | 15.4 | 0.64 ±0.07 | 1.70 | 0.06 |
| II-38(0039) | 11 | 5 | 29 | M | 64 | 12 | 9 | V | 160.4 | 13.4 | 0.72 ±0.08 | 2.04 | 0.06 |
| II-38(0040) | 4 | 4 | 28 | M | 64 | 12 | 25 | V | 134.2 | 14.8 | 0.97 ±0.09 | 2.65 | 0.11 |
| II-38(0041) | 15 | | 7 | F | 64 | 12 | 28 | V | 169.6 | 21.5 | 0.47 ±0.05 | 1.23 | 0.06 |
| II-39(0002) | 3 | 10 | 8 | M | 64 | 8 | 31 | V | 136.6 | 15.5 | 1.43 ±0.09 | 3.83 | 0.16 |
| Pennsylvania | | | | | | | | | | | | | |
| II-3(0003) | 5 | | 13 | M | 63 | 8 | 1 | V | 113.7 | 12.8 | 1.17 ±0.13 | 3.37 | 0.13 |
| II-3(0005) | 24 | 2 | 25 | M | 63 | 8 | 11 | V | 93.5 | 16.3 | 0.67 ±0.09 | 1.76 | 0.12 |
| II-3(0008) | 18 | 2 | 28 | M | 64 | 3 | 5 | V | 175.4 | 21.6 | 0.91 ±0.10 | 2.44 | 0.11 |
| II-4(0020) | 24 | 11 | 21 | M | 64 | 1 | 25 | V | 185.5 | 14.1 | 0.51 ±0.06 | 1.46 | 0.04 |
| II-4(0023) | 19 | 5 | 8 | M | 64 | 3 | 25 | V | 150.6 | 16.5 | 0.71 ±0.06 | 1.93 | 0.08 |
| II-4(0026) | 13 | 4 | 24 | F | 64 | 4 | 15 | V | 132.7 | 14.4 | 0.64 ±0.06 | 1.76 | 0.07 |
| II-4(0029) | 6 | 8 | 4 | M | 64 | 7 | 11 | V | 95.1 | 8.1 | 0.98 ±0.11 | 2.81 | 0.08 |
| II-4(0031) | 24 | 1 | 27 | M | 64 | 9 | 30 | V | 122.1 | 10.5 | 0.57 ±0.08 | 1.50 | 0.05 |
| II-19(0043) | 20 | 4 | 4 | M | 63 | 7 | 13 | R, V | 150.1 | 23.1 | 0.69 ±0.07 | 1.79 | 0.11 |
| II-19(0046) | 22 | 4 | 18 | M | 63 | 7 | 27 | V | 93.4 | 15.9 | 0.62 ±0.09 | 1.64 | 0.11 |
| II-19(0047) | 10 | 5 | 28 | M | 63 | 8 | 1 | V | 126.4 | 18.5 | 0.85 ±0.08 | 2.34 | 0.13 |
| II-19(0049) | 25 | 6 | 28 | M | 63 | 8 | 24 | V | 94.8 | 14.9 | 0.70 ±0.09 | 1.94 | 0.05 |
| II-19(0050) | 5 | 7 | 8 | M | 63 | 9 | 9 | V | 103.7 | 8.5 | 1.54 ±0.17 | 4.67 | 0.13 |
| II-19(0052) | 24 | 5 | 21 | M | 63 | 10 | 22 | V | 136.8 | 18.2 | 1.03 ±0.10 | 2.72 | 0.14 |
| II-19(0063) | 14 | 6 | 5 | M | 64 | 4 | 21 | V | 121.1 | 13.5 | 0.70 ±0.07 | 2.02 | 0.08 |
| Vermont | | | | | | | | | | | | | |
| I-6(0040) | 25 | 1 | 26 | M | 64 | 4 | 30 | V | 133.9 | 18.2 | 0.67 ±0.06 | 1.74 | 0.09 |
| I-6(0040) | 25 | 1 | 26 | M | 64 | 4 | 30 | V | 133.9 | 18.2 | 0.59 ±0.06 | 1.62 | 0.08 |
| I-6(0050) | 22 | 9 | 25 | F | 64 | 11 | 14 | V | 100.8 | 17.0 | 0.67 ±0.07 | 1.76 | 0.11 |
| I-6(0050) | 22 | 9 | 25 | F | 64 | 11 | 14 | V | 100.8 | 17.0 | 0.81 ±0.08 | 2.09 | 0.14 |
| I-6(0052) | 15 | 1 | 14 | M | 64 | 12 | 29 | V | 101.1 | [illegible] | 1.66 ±0.11 | 4.56 | 0.24 |
| I-6(0052) | 15 | 1 | 14 | M | 64 | 12 | 29 | V | 101.1 | [illegible] | 1.80 ±0.12 | 4.70 | 0.25 |
| I-13(0005) | 6 | 10 | 21 | F | 64 | 8 | 14 | V | 207.6 | [illegible] | 0.89 ±0.06 | 2.51 | 0.09 |
| Southeast | | | | | | | | | | | | | |
| Kentucky | | | | | | | | | | | | | |
| III-10(0001) | 10 | 6 | 23 | F | 63 | 8 | 10 | R, V | 122.4 | 17.9 | 0.87 ±0.09 | 2.24 | 0.13 |
| III-10(0001) | 10 | 6 | 23 | F | 63 | 8 | 10 | R, V | 122.4 | 17.9 | 0.87 ±0.10 | 2.34 | 0.15 |
| III-10(0002) | 14 | 7 | 19 | F | 64 | 7 | 15 | V | 181.6 | 22.4 | 0.82 ±0.06 | 2.33 | 0.10 |
| III-10(0002) | 14 | 7 | 19 | F | 64 | 7 | 15 | V | 181.6 | 22.4 | 0.89 ±0.06 | 2.43 | 0.11 |
| III-10(0003) | 24 | 5 | 8 | F | 64 | 9 | 9 | V | 122.9 | 19.2 | 0.80 ±0.07 | 2.10 | 0.15 |
| III-10(0003) | 24 | 5 | 8 | F | 64 | 9 | 9 | V | 122.9 | 19.2 | 0.69 ±0.05 | 1.86 | 0.11 |
| III-10(0003) | 24 | 5 | 8 | F | 64 | 9 | 9 | V | 122.9 | 19.2 | 0.82 ±0.06 | 2.19 | 0.13 |
| Maryland | | | | | | | | | | | | | |
| III-6(0001) | 9 | | 28 | M | 63 | 6 | 2 | V | 137.2 | 10.0 | 0.82 ±0.15 | 3.55 | 0.06 |
| III-7(0024) | 18 | 2 | 2 | M | 63 | 4 | 6 | V | 106.5 | 14.1 | 0.74 ±0.09 | 1.95 | 0.10 |
| III-7(0024) | 18 | 2 | 2 | M | 63 | 4 | 6 | V | 106.5 | 14.1 | 0.87 ±0.10 | 2.26 | 0.12 |
| III-7(0025) | 17 | 1 | 6 | M | 63 | 5 | 12 | V | 150.1 | 19.4 | 0.76 ±0.08 | 2.02 | 0.10 |
| III-7(0026) | 22 | | 25 | M | 63 | 4 | 4 | V | 130.8 | 16.3 | 0.66 ±0.10 | 1.73 | 0.08 |
| III-7(0027) | 15 | 1 | 2 | M | 63 | 6 | 6 | V | 219.0 | 27.3 | 1.02 ±0.08 | 2.72 | 0.13 |
| III-7(0028) | 20 | | 6 | M | 63 | 4 | 30 | V | 174.4 | 24.3 | 0.62 ±0.07 | 1.66 | 0.09 |
| III-7(0029) | 20 | 3 | 21 | M | 63 | 5 | 23 | V | 97.2 | 16.2 | 0.71 ±0.08 | 1.86 | 0.12 |
| III-7(0029) | 20 | 3 | 21 | M | 63 | 5 | 23 | V | 97.2 | 16.2 | 0.80 ±0.11 | 2.06 | 0.13 |
| III-7(0030) | 14 | | 26 | F | 63 | 4 | 3 | V | 137.7 | 19.2 | 0.75 ±0.08 | 1.99 | 0.10 |
| III-7(0031) | 13 | 6 | 24 | M | 63 | 5 | 8 | V | 149.6 | 16.9 | 1.17 ±0.10 | 3.21 | 0.13 |
| III-7(0036) | 24 | | | M | 63 | 4 | 21 | V | 123.7 | 15.6 | 0.46 ±0.07 | 1.18 | 0.06 |
| III-7(0036) [c] | 24 | | | M | 63 | 4 | 21 | V | 123.7 | 15.6 | 0.59 ±0.07 | 1.56 | 0.07 |
| III-7(0037) | 19 | 9 | 20 | F | 63 | 5 | 14 | V | 157.0 | 21.5 | 1.04 ±0.09 | 2.75 | 0.14 |
| III-7(0038) | 25 | 6 | 23 | M | 63 | 5 | 23 | V | 200.8 | 25.7 | 0.94 ±0.06 | 1.27 | 0.06 |
| III-7(0039) | 19 | | 5 | M | 63 | 5 | 18 | V | 181.3 | 24.9 | 0.74 ±0.07 | 1.34 | 0.10 |
| North Carolina | | | | | | | | | | | | | |
| III-13(0014) | 19 | 4 | 21 | M | 64 | 3 | 3 | V | 139.2 | 16.3 | 1.00 ±0.07 | 2.74 | 0.12 |
| Virginia | | | | | | | | | | | | | |
| III-5(0002) | 6 | 8 | 7 | M | 63 | 5 | 28 | R, V | 108.7 | 9.9 | 1.81 ±0.22 | 4.95 | 0.16 |
| Central | | | | | | | | | | | | | |
| Illinois | | | | | | | | | | | | | |
| V-27(0002) | 18 | 11 | 27 | M | 64 | 4 | 13 | V | 137.4 | 17.5 | 0.41 ±0.05 | 1.08 | 0.05 |
| V-27(0002) [c] | 18 | 11 | 27 | M | 64 | 4 | 13 | V | 137.4 | 17.5 | 0.50 ±0.05 | 1.30 | 0.06 |
| V-27(0002) [d] | 18 | 11 | 27 | M | 64 | 4 | 13 | V | 137.4 | 17.5 | 0.40 ±0.05 | 1.05 | 0.05 |
| V-27(0003) | 19 | 6 | 25 | M | 64 | 9 | 5 | V | 98.8 | 12.7 | 0.60 ±0.07 | 1.60 | 0.08 |
| V-27(0003) [c] | 19 | 6 | 25 | M | 64 | 9 | 5 | V | 98.8 | 12.7 | 0.59 ±0.07 | 1.60 | 0.08 |

## Table 1—Continued

| Region, state, and sample number | Age at death [a] |  |  | Sex | Date of death |  |  | Bone type [b] | Original weight (g) | Ash weight (g) | pCi strontium-90/g of: |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Yrs | Mo | Day |  | Yr | Mo | Day |  |  |  | Ash ±2s.d. C.E. | Calcium | Bone |
| **Illinois—continued** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| V-27(0005) | 20 | 1 | 14 | M | 64 | 12 | 28 | R | 95.3 | 20.0 | 0.37 ±0.04 | 0.97 | 0.08 |
| **Michigan** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| V-5(0008) | 20 |  |  | F | 64 | 8 | 29 | V | 137.8 | 16.1 | 0.62 ±0.06 | 1.67 | 0.07 |
| V-6(0002) | 2 | 8 | 26 | M | 64 | 6 | 24 | V | 142.6 | 14.6 | 1.18 ±0.09 | 3.19 | 0.12 |
| V-6(0003) | 22 | 6 | 18 | M | 64 | 12 | 15 | V | 167.1 | 24.2 | 0.68 ±0.06 | 1.75 | 0.10 |
| **Minnesota** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| VI-6(0004) | 15 | 4 |  | F | 62 | 11 | 18 | R,V,S | 176.9 | 26.0 | 0.74 ±0.13 | 2.46 | 0.14 |
| VI-16(0001) | 10 | 4 | 5 | F | 63 | 11 | 12 | V | 221.9 | 23.6 | 1.53 ±0.10 | 4.07 | 0.16 |
| VI-16(0003) | 19 | 5 | 29 | F | 64 | 10 | 6 | V | 140.7 | 12.3 | 1.02 ±0.10 | 2.71 | 0.09 |
| VI-19(0005) | 16 | 10 | 2 | M | 64 | 2 | 2 | V | 167.3 | 18.7 | 0.60 ±0.06 | 1.66 | 0.07 |
| VI-19(0006) | 4 | 5 | 3 | F | 64 | 2 | 14 | V | 115.9 | 9.2 | 0.80 ±0.11 | 2.21 | 0.06 |
| VI-19(0008) | 29 | 8 | 24 | F | 64 | 2 | 25 | V | 93.5 | 10.9 | 0.69 ±0.10 | 1.70 | 0.08 |
| VI-19(0011) | 7 | 4 | 16 | F | 64 | 3 | 24 | V | 146.0 | 14.3 | 0.83 ±0.09 | 2.27 | 0.08 |
| VI-19(0014) | 9 | 1 | 11 | M | 64 | 5 | 9 | V | 109.8 | 10.1 | 2.17 ±0.16 | 6.04 | 0.20 |
| VI-19(0015) | 23 |  |  | M | 64 | 5 | 22 | V | 177.1 | 23.2 | 0.90 ±0.06 | 2.35 | 0.12 |
| VI-19(0017) | 11 | 5 | 16 | F | 64 | 6 | 9 | V | 150.6 | 14.3 | 0.67 ±0.07 | 1.83 | 0.06 |
| VI-19(0019) | 18 | 2 | 9 | M | 64 | 8 | 18 | V | 121.4 | 19.5 | 0.60 ±0.02 | 1.59 | 0.10 |
| VI-19(0022) | 9 | 7 | 16 | F | 64 | 9 | 10 | V | 145.9 | 12.0 | 0.93 ±0.11 | 2.53 | 0.08 |
| VI-19(0023) | 7 | 1 | 8 | M | 64 | 10 | 6 | V | 128.9 | 12.5 | 2.21 ±0.04 | 6.03 | 0.22 |
| VI-19(0039) | 17 | 6 | 2 | M | 64 | 12 | 8 | V | 181.8 | 20.2 | 0.75 ±0.06 | 2.01 | 0.08 |
| VI-19(0040) | 8 | 11 | 29 | F | 64 | 12 | 29 | V | 134.7 | 10.5 | 1.56 ±0.12 | 4.28 | 0.12 |
| VI-19(0041) | 18 |  |  | M | 64 | 12 | 21 | V | 140.9 | 13.5 | 0.63 ±0.07 | 1.73 | 0.06 |
| VI-19(0041) [c] | 18 |  |  | M | 64 | 12 | 29 | V | 140.9 | 13.5 | 0.57 ±0.07 | 1.53 | 0.06 |
| **Missouri** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| VI-7(0032) | 22 | 8 | 11 | F | 64 | 10 | 8 | V | 159.2 | 6.6 | 0.50 ±0.09 | 1.91 | 0.02 |
| **Ohio** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| V-19(0086) | 4 | 11 | 1 | F | 63 | 1 | 27 | V | 155.8 | 17.7 | 0.63 ±0.09 | 1.68 | 0.07 |
| V-19(0123) | 4 | 7 | 11 | M | 64 | 1 | 3 | V | 118.1 | 11.5 | 1.25 ±0.12 | 3.45 | 0.12 |
| V-19(0137) | 3 | 7 | 9 | F | 64 | 2 | 21 | V | 130.2 | 8.6 | 1.05 ±0.11 | 3.13 | 0.07 |
| V-19(0141) |  | 5 | 1 | F | 64 | 3 | 12 | V | 55.6 | 5.3 | 1.96 ±0.23 | 5.65 | 0.19 |
| V-19(0161) | 3 | 3 | 9 | F | 64 | 4 | 23 | V | 48.9 | 4.1 | 1.64 ±0.21 | 4.33 | 0.14 |
| V-19(0162) | 1 | 9 | 13 | M | 64 | 4 | 30 | V | 54.3 | 4.1 | 2.00 ±0.24 | 5.34 | 0.15 |
| V-19(0166) | 7 | 4 | 7 | F | 64 | 5 | 12 | V | 88.2 | 7.3 | 2.18 ±0.18 | 6.24 | 0.18 |
| V-19(0172) | 0 | 6 |  | F | 64 | 7 | 4 | V | 80.1 | 6.6 | 2.20 ±0.20 | 6.43 | 0.18 |
| V-19(0177) | 1 | 10 | 25 | M | 64 | 7 | 17 | V | 76.2 | 4.7 | 1.88 ±0.20 | 5.33 | 0.12 |
| V-19(0181) | 2 | 4 | 11 | M | 64 | 7 | 27 | V | 98.7 | 6.3 | 2.57 ±0.20 | 7.52 | 0.16 |
| V-19(0185) | 2 | 1 | 3 | F | 64 | 8 | 7 | V | 74.6 | 6.5 | 3.19 ±0.22 | 8.73 | 0.28 |
| V-19(0186) | 4 | 4 | 29 | F | 64 | 8 | 10 | V | 73.6 | 7.8 | 1.48 ±0.15 | 4.02 | 0.16 |
| V-19(0188) | 1 | 1 | 2 | M | 64 | 7 | 25 | V | 74.7 | 6.3 | 2.14 ±0.21 | 6.19 | 0.18 |
| V-19(0189) | 6 |  | 28 | M | 64 | 8 | 3 | V | 170.4 | 14.7 | 2.15 ±0.13 | 6.11 | 0.19 |
| V-19(0200) | 14 | 4 | 10 | F | 64 | 10 | 3 | V | 86.6 | 12.8 | 0.99 ±0.09 | 2.72 | 0.15 |
| V-19(0200) [c] | 14 | 4 | 10 | F | 64 | 10 | 3 | V | 86.6 | 12.8 | 1.05 ±0.09 | 2.77 | 0.16 |
| V-19(020[illegible]) | 5 | 6 | 24 | F | 64 | 8 | 16 | V | 83.6 | 9.8 | 1.27 ±0.13 | 3.43 | 0.15 |
| V-19(0207) | 2 | 3 | 24 | F | 64 | 10 | 30 | V | 71.9 | 5.9 | 2.50 ±0.28 | 7.10 | 0.21 |
| V-19(0208) | 2 |  | 15 | M | 64 | 11 | 29 | V | 47.5 | 3.5 | 1.01 ±0.22 | 3.06 | 0.07 |
| V-19(0209) | 3 | 6 | 21 | F | 64 | 11 | 26 | V | 93.9 | 8.5 | 2.25 ±0.17 | 6.53 | 0.20 |
| V-19(0210) | 1 |  | 24 | F | 64 | 10 | 11 | V | 48.3 | 5.2 | 2.45 ±0.23 | 7.17 | 0.26 |
| V-19(0211) |  |  | 1 | F | 64 | 11 | 23 | V | 56.2 | 4.5 | 0.81 ±0.17 | 2.50 | 0.06 |
| V-19(0214) | 1 | 10 | 8 | F | 64 | 10 | 17 | V | 50.7 | 5.4 | 2.76 ±0.23 | 8.21 | 0.29 |
| V-19(0219) | 6 | 4 | 19 | F | 64 | 9 | 1 | V | 114.3 | 9.8 | 1.08 ±0.11 | 3.04 | 0.09 |
| V-26(0005) | 23 | 2 | 13 | M | 64 | 5 | 24 | V | 91.3 | 13.9 | 0.61 ±0.12 | 1.59 | 0.09 |
| V-31(0001) | 7 | 7 |  | M | 64 | 2 | 21 | V | 200.2 | 22.0 | 0.67 ±0.05 | 1.71 | 0.07 |
| **Wisconsin** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| V-03(0042) | 3 | 6 | 8 | M | 63 | 6 | 2 | V | 156.8 | 14.2 | 1.08 ±0.13 | 3.04 | 0.10 |
| V-03(0044) | 8 | 2 | 2 | F | 63 | 6 | 25 | V | 225.7 | 23.3 | 0.67 ±0.07 | 1.81 | 0.67 |
| V-03(0051) | 5 | 4 | 29 | M | 63 | 8 | 6 | V | 215.7 | 22.2 | 1.16 ±0.09 | 3.17 | 0.12 |
| V-03(0053) | 9 | 6 | 24 | M | 63 | 8 | 3 | V | 178.4 | 14.7 | 0.76 ±0.11 | 2.09 | 0.07 |
| V-03(0053) [c] | 9 | 6 | 24 | M | 63 | 8 | 3 | V | 178.4 | 14.7 | 0.67 ±0.09 | 2.21 | 0.06 |
| V-03(0055) | 3 | 5 | 17 | M | 63 | 7 | 31 | V | 155.9 | 12.8 | 1.76 ±0.15 | 4.97 | 0.14 |
| V-03(0062) |  | 4 | 11 | M | 63 | 9 | 9 | V | 313.5 | 19.4 | 0.33 ±0.05 | 0.96 | 0.02 |
| V-03(0063) | 14 | 2 |  | M | 63 | 9 | 12 | V | 153.9 | 16.1 | 1.26 ±0.11 | 3.52 | 0.14 |
| V-03(0063) [c] | 14 | 2 |  | M | 63 | 9 | 12 | V | 153.9 | 16.1 | 1.69 ±0.12 | 3.75 | 0.18 |
| V-03(0067) | 4 | 8 | 14 | F | 63 | 9 | 24 | V | 119.2 | 11.0 | 1.36 ±0.15 | 3.93 | 0.13 |
| V-03(0068) | 4 | 11 |  | F | 63 | 10 | 2 | V | 155.8 | 14.7 | 1.10 ±0.11 | 3.12 | 0.10 |
| V-03(0069) | 3 | 11 | 1 | M | 63 | 10 | 7 | V | 210.6 | 18.7 | 1.12 ±0.10 | 3.16 | 0.10 |
| V-03(0070) | 15 | 8 | 11 | F | 63 | 10 | 8 | V | 156.5 | 15.1 | 0.74 ±0.12 | 2.09 | 0.07 |
| V-03(0070) [c] | 15 | 8 | 11 | F | 63 | 10 | 8 | V | 156.5 | 15.1 | 0.79 ±0.09 | 2.15 | 0.08 |
| V-03(0079) | 4 | 5 | 18 | F | 63 | 11 | 14 | V | 131.8 | 13.0 | 1.69 ±0.15 | 4.60 | 0.17 |
| V-03(0081) | 4 | 11 | 7 | M | 63 | 11 | 22 | V | 188.2 | 15.0 | 1.40 ±0.12 | 4.04 | 0.11 |
| V-03(0082) | 2 | 5 | 2 | M | 63 | 11 | 25 | V | 128.2 | 12.3 | 2.03 ±0.18 | 5.49 | 0.20 |
| V-03(0084) | 12 | 11 | 23 | M | 63 | 11 | 29 | V | 237.4 | 23.9 | 0.59 ±0.07 | 1.59 | 0.06 |
| V-03(0093) | 6 | 6 | 17 | M | 64 | 1 | 7 | V | 154.6 | 14.1 | 1.19 ±0.09 | 3.27 | 0.11 |
| V-03(0095) | 3 | 5 | 13 | M | 64 | 1 | 5 | V | 158.4 | 13.2 | 0.63 ±0.07 | 1.73 | 0.05 |
| V-03(0097) | 3 | 9 | 3 | M | 64 | 1 | 22 | V | 144.3 | 16.3 | 1.25 ±0.12 | 3.37 | 0.14 |
| V-03(0101) | 2 | 9 | 29 | F | 64 | 1 | 24 | V | 148.7 | 11.9 | 1.09 ±0.10 | 3.17 | 0.09 |

## Table 1—Continued

| Region, state, and sample number | Age at death [a] | | | Sex | Date of death | | | Bone type[b] | Original weight (g) | Ash weight (g) | pCi strontium-90/g of: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yrs | Mo | Day | | Yr | Mo | Day | | | | Ash ±2s.d. C.E. | Calcium | Bone |
| V-03(0102) | 10 | 11 | 26 | F | 64 | 1 | 28 | V | 222.5 | 21.9 | 0.96 ±0.07 | 2.70 | 0.09 |
| V-03(0103) | | 7 | 8 | F | 64 | 2 | 6 | V | 130.0 | 11.2 | 0.93 ±0.09 | 2.67 | 0.08 |
| V-03(0109) | 2 | 2 | 10 | M | 64 | 2 | 15 | V | 106.5 | 8.8 | 1.60 ±0.15 | 4.35 | 0.13 |
| V-03(0110) | 3 | 1 | 28 | M | 64 | 2 | 26 | V | 118.0 | 9.8 | 1.40 ±0.12 | 3.95 | 0.12 |
| V-03(0118) | 2 | 5 | 18 | M | 64 | 4 | 2 | V | 160.3 | 14.8 | 1.09 ±0.09 | 3.04 | 0.10 |
| V-03(0123) | 3 | 5 | 13 | M | 64 | 4 | 17 | V | 165.8 | 16.2 | 1.34 ±0.10 | 3.68 | 0.13 |
| V-03(0125) | 7 | 8 | 17 | F | 64 | 4 | 19 | V | 125.1 | 11.4 | 0.74 ±0.09 | 2.03 | 0.07 |
| V-03(0126) | 14 | 5 | 29 | M | 64 | 4 | 19 | V | 175.2 | 22.4 | 1.05 ±0.07 | 2.76 | 0.13 |
| V-03(0126) [c] | 14 | 5 | 29 | M | 64 | 4 | 19 | V | 175.2 | 22.4 | 0.93 ±0.06 | 2.61 | 0.12 |
| V-03(0134) | 4 | 4 | 27 | M | 64 | 5 | 27 | V | 141.8 | 13.8 | 0.74 ±0.08 | 1.99 | 0.07 |
| V-03(0137) | 4 | 2 | 6 | M | 64 | 6 | 12 | V | 103.6 | 10.1 | 1.02 ±0.10 | 2.84 | 0.10 |
| V-03(0145) | 3 | 5 | 18 | M | 64 | 7 | 17 | V | 157.0 | 14.1 | 1.28 ±0.09 | 3.51 | 0.12 |
| V-03(0152) | 16 | 2 | 2 | F | 64 | 9 | 29 | V | 202.4 | 17.3 | 0.84 ±0.07 | 2.19 | 0.11 |
| V-03(0152) [c] | 16 | 2 | 2 | F | 64 | 9 | 29 | V | 202.4 | 17.3 | 0.72 ±0.06 | 1.94 | 0.09 |
| V-03(0152) [d] | 16 | 2 | 2 | F | 64 | 9 | 29 | V | 134.9 | 17.3 | 0.84 ±0.08 | 2.28 | 0.11 |
| V-03(0182) | 8 | 4 | 11 | M | 64 | 12 | 30 | V | 200.1 | 19.2 | 1.41 ±0.08 | 3.86 | 0.14 |
| Louisiana | | | | | | | | | | | | | |
| VII-8(0014) | 21 | 1 | 6 | M | 63 | 10 | 10 | V | 115.1 | 18.7 | 0.88 ±0.07 | 2.36 | 0.14 |
| VII-8(0014) [c] | 21 | 1 | 6 | M | 63 | 10 | 10 | V | 115.1 | 18.7 | 0.98 ±0.07 | 2.49 | 0.16 |
| VII-8(0015) | 2 | 3 | 28 | M | 63 | 11 | 9 | R, V | 149.4 | 15.6 | 1.93 ±0.13 | 5.24 | 0.20 |
| VII-8(0018) | 21 | | | M | 63 | 12 | 26 | V | 122.3 | 18.1 | 0.70 ±0.06 | 1.83 | 0.10 |
| VII-8(0018) [c] | 21 | | | M | 63 | 12 | 26 | V | 122.3 | 18.1 | 0.57 ±0.03 | 1.55 | 0.09 |
| VII-8(0024) | 24 | 5 | 18 | M | 64 | 4 | 4 | V | 104.5 | 16.2 | 0.54 ±0.06 | 1.44 | 0.09 |
| VII-8(0024) [c] | 24 | 5 | 18 | M | 64 | 4 | 4 | V | 104.5 | 16.2 | 0.57 ±0.07 | 1.49 | 0.09 |
| VII-8(0036) | 18 | 8 | 25 | F | 64 | 10 | 20 | V | 175.4 | 19.9 | 1.45 ±0.09 | 3.86 | 0.16 |
| VII-8(0037) | 11 | 11 | 6 | M | 64 | 11 | 15 | V | 166.2 | 19.2 | 1.26 ±0.08 | 3.45 | 0.15 |
| VII-8(0038) | 23 | 1 | 22 | M | 64 | 12 | 27 | V | 99.9 | 17.7 | 1.11 ±0.09 | 3.12 | 0.02 |
| VII-8(0038) [c] | 23 | 1 | 22 | M | 64 | 12 | 27 | V | 99.9 | 17.7 | 1.04 ±0.07 | 2.83 | 0.19 |
| VII-8(0038) [d] | 23 | 1 | 22 | M | 64 | 12 | 27 | V | 99.9 | 17.7 | 1.06 ±0.08 | 2.57 | 0.19 |
| VII-8(0039) | 7 | 9 | 20 | F | 64 | 12 | 28 | V | 179.0 | 13.8 | 1.55 ±0.11 | 4.48 | 0.12 |
| Tennessee | | | | | | | | | | | | | |
| IV-9(0013) | 12 | 5 | | F | 63 | 12 | 29 | V | 137.1 | 22.0 | 1.11 ±0.11 | 2.83 | 0.18 |
| IV-14(0005) | 20 | 9 | | M | 63 | 3 | 27 | V | 240.1 | 32.0 | 0.90 ±0.09 | 2.34 | 0.12 |
| IV-14(0007) | 20 | 6 | 13 | M | 63 | 12 | 6 | R, V | 132.7 | 16.9 | 0.55 ±0.06 | 1.47 | 0.07 |
| IV-14(0007) [c] | 20 | 6 | 13 | M | 63 | 12 | 6 | R, V | 132.7 | 16.9 | 0.65 ±0.07 | 1.74 | 0.08 |
| Southwest | | | | | | | | | | | | | |
| Arizona | | | | | | | | | | | | | |
| IX-27(0002) | 5 | 7 | 25 | F | 64 | 3 | 29 | V | 123.9 | 10.4 | 0.93 ±0.14 | 2.50 | 0.08 |
| California | | | | | | | | | | | | | |
| IX-8(0032) | | | 1 | M | 64 | 11 | 18 | R,V,S | 106.2 | 10.6 | 0.35 ±0.07 | 0.96 | 0.18 |
| IX-9(0012) | 23 | 8 | 26 | M | 63 | 3 | 13 | V | 176.6 | 23.3 | 0.32 ±0.05 | 0.84 | 0.04 |
| IX-9(0012) [c] | 23 | 8 | 26 | M | 63 | 3 | 13 | V | 176.6 | 23.3 | 0.99 ±0.19 | 1.34 | 0.07 |
| IX-17(0002) | 23 | 7 | 20 | M | 63 | 10 | 26 | V | 138.7 | 15.1 | 0.94 ±0.10 | 2.52 | 0.10 |
| IX-17(0002) [c] | 23 | 7 | 20 | M | 63 | 10 | 26 | V | 138.7 | 15.1 | 1.02 ±0.11 | 2.84 | 0.11 |
| IX-31(0003) | 24 | | 10 | M | 64 | 4 | 11 | V | 127.0 | 17.1 | 0.58 ±0.06 | 1.55 | 0.08 |
| Colorado | | | | | | | | | | | | | |
| VIII-3(0005) | 23 | 2 | 4 | M | 63 | 7 | 25 | S | 231.8 | 13.1 | 0.64 ±0.10 | 1.72 | 0.04 |
| VIII-4(0002) | 5 | 11 | 7 | M | 62 | 11 | 21 | V | 118.5 | 11.4 | 0.36 ±0.02 | 1.00 | 0.03 |
| Texas | | | | | | | | | | | | | |
| VII-4(0002) | 8 | 9 | | F | 64 | 7 | 4 | V | 79.4 | 11.0 | 0.50 ±0.08 | 1.37 | 0.07 |
| VII-4(0003) | 11 | 3 | 28 | M | 64 | 7 | 6 | V | 89.4 | 9.5 | 1.07 ±0.12 | 2.94 | 0.11 |
| VII-4(0004) | 3 | 6 | 27 | F | 64 | 8 | 11 | V | 130.7 | 7.3 | 1.58 ±0.16 | 4.99 | 0.09 |
| VII-4(0006) | 16 | 8 | 16 | M | 64 | 9 | 19 | V | 131.0 | 14.4 | 0.74 ±0.07 | 2.02 | 0.08 |
| VII-5(0001) | 13 | 5 | 12 | M | 62 | 10 | 7 | V | 178.7 | 18.9 | 0.75 ±0.10 | 1.89 | 0.08 |
| VII-5(0002) | 11 | 8 | 20 | F | 63 | 1 | 29 | V | 160.8 | 16.8 | 0.67 ±0.08 | 1.83 | 0.07 |
| VII-11(0005) | 18 | | | M | 63 | 11 | 15 | R, V | 107.0 | 13.4 | 0.67 ±0.06 | 1.77 | 0.08 |
| VII-11(0005) [c] | 18 | | | M | 63 | 11 | 15 | R, V | 107.0 | 13.4 | 0.69 ±0.09 | 1.85 | 0.09 |
| VII-12(0004) | 14 | 11 | 7 | F | 64 | 12 | 23 | V | 119.5 | 15.0 | 0.34 ±0.06 | 0.90 | 0.04 |
| VII-17(0014) | 25 | | 15 | M | 64 | 5 | 8 | V | 122.0 | 15.6 | 0.53 ±0.06 | 1.45 | 0.07 |
| VII-17(0015) | 11 | | | M | 64 | 10 | 29 | T,FB | 123.2 | 20.6 | 0.94 ±0.07 | 2.34 | 0.16 |
| Northwest | | | | | | | | | | | | | |
| Alaska | | | | | | | | | | | | | |
| IX-29(0001) | 23 | 5 | 24 | M | 64 | 4 | 19 | R | 97.3 | 27.8 | 0.24 ±0.03 | 0.62 | 0.07 |
| IX-29(0002) | 2 | 1 | 25 | F | 64 | 6 | 19 | R | 15.3 | 4.0 | 1.26 ±0.20 | 3.23 | 0.33 |
| Washington | | | | | | | | | | | | | |
| IX-7(0022) | 4 | 9 | 23 | F | 63 | 6 | 17 | V | 124.9 | 9.6 | 1.32 ±0.14 | 3.88 | 0.10 |

[a] Or time of surgical procedure.
[b] R, rib; V, vertebra; S, sternum; FM, femur; T, tibia; FB, fibula.
[c] Duplicate analysis.
[d] Replicate analysis.

**Table 2. Summary of results**

| Age group and year of death[b] | Number | pCi $^{90}$Sr/g calcium[a] | | |
|---|---|---|---|---|
| | | Mean | Minimum | Maximum |
| 0–4 years | | | | |
| 1961 | 3 | 2.7 | 1.8 | 3.4 |
| 1962 | 50 | 3.3 | 0.8 | 9.7 |
| 1963 | 44 | 4.5 | 1.0 | 13.0 |
| 1964 | 67 | 4.4 | 1.0 | 8.7 |
| 5–9 years | | | | |
| 1961 | 1 | 2.7 | 2.7 | 2.7 |
| 1962 | 33 | 2.7 | 1.0 | 9.4 |
| 1963 | 43 | 3.9 | 1.8 | 9.1 |
| 1964 | 64 | 3.6 | 1.2 | 7.0 |
| 10–14 years | | | | |
| 1961 | 4 | 1.8 | 1.2 | 2.8 |
| 1962 | 28 | 2.1 | 0.8 | 3.5 |
| 1963 | 47 | 2.9 | 1.1 | 9.0 |
| 1964 | 56 | 3.1 | 0.9 | 5.7 |
| 15–19 years | | | | |
| 1961 | 0 | | | |
| 1962 | 31 | 2.2 | 0.9 | 4.6 |
| 1963 | 73 | 2.6 | 1.0 | 7.0 |
| 1964 | 58 | 2.9 | 1.2 | 6.1 |
| 20–25 years | | | | |
| 1961 | 0 | | | |
| 1962 | 29 | 1.8 | 0.9 | 3.5 |
| 1963 | 61 | 2.2 | 0.9 | 5.0 |
| 1964 | 52 | 2.2 | 0.8 | 4.3 |
| Total samples | | | | |
| 1961 | 8 | | | |
| 1962 | 171 | | | |
| 1963 | 268 | | | |
| 1964 | 297 | | | |

[a] Includes all data through 1964.
[b] Or surgical procedure.

### *Laboratory procedures*

The samples are analyzed at the Northeastern Radiological Health Laboratory of the Division of Radiological Health, at Winchester, Massachusetts. An yttrium fraction is separated from the bone ash by extraction with 2-thenoyltrifluoroacetone (TTA). The strontium-90 content is then calculated (*2,3*) from the yttrium-90 activity. "Blind" duplicate analyses are performed on 10 to 20 percent of the samples. In addition, pools of animal bone ash and adult human bone ash are analyzed in replicate on a continuing basis.

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(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Rad Health Data 5:231–239 (May 1964).

(*3*) NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY, PUBLIC HEALTH SERVICE. Analysis of environmental samples chemical and radiochemical procedures. NERHL 64-1 (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone. Rad Health Data 5:620–628 (December 1964).

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# ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semi-annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Bettis Atomic Power Laboratory, the Feed Materials Production Center, Knolls Atomic Power Laboratory, and S1C Prototype Reactor Facility.

---

[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

## 1. Bettis Atomic Power Laboratory January–June 1965[2]

*Westinghouse Electric Corporation*
*Pittsburgh, Pennsylvania*

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pennsylvania. Routine environmental monitoring data from the sampling locations shown in figure 1 indicate that environmental radiation concentrations resulting from laboratory operations are well within Atomic Energy Commission prescribed limits.

### *Liquid radioactive waste*

Liquid effluent discharged from the Laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta-gamma activity, and quarterly for strontium-90 activity.

The average concentration of gross beta radioactivity in the liquid effluent during the first 6 months of 1965 was 3,000 pCi/liter. This was considerably higher than the average concentration of 180 pCi/liter observed in the second half of 1964, although it remained well below the limits prescribed by the AEC. The average concentrations of strontium-90 for the fourth quarter of 1964 and the first and second quarters of 1965 were 36 pCi/liter, 84 pCi/liter, and 140 pCi/liter, respectively.

### *Background monitoring stations*

Beta-gamma background radiation levels are continuously monitored and recorded at monitoring stations located at the periphery of the laboratory property. Average readings at these stations are summarized in table 1.

Beta-gamma radiation intensities averaged 0.022 mR/hr during this period. This average is not significantly different from the background radiation intensities measured during

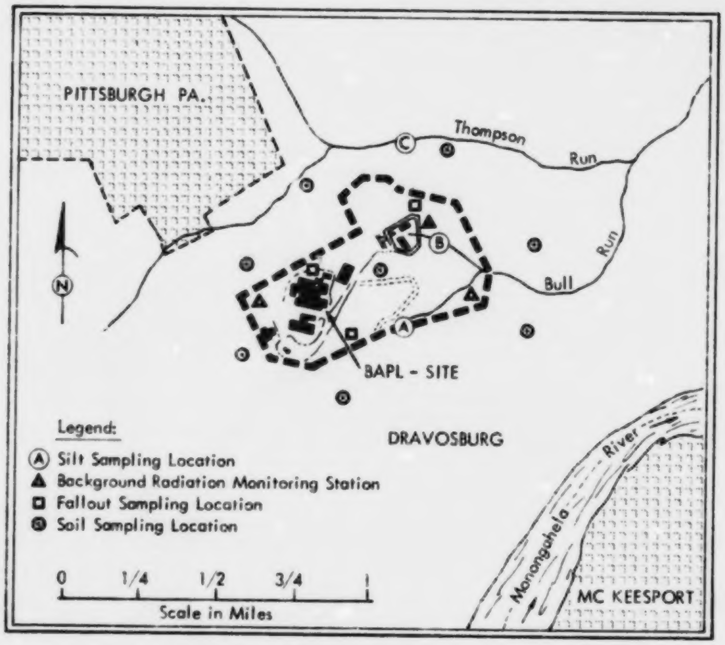
PITTSBURGH PA.
Thompson
Run
Ⓒ
Ⓑ
Ⓐ
Bull
Run
Ⓝ
BAPL - SITE
DRAVOSBURG
River
Monongahela
MC KEESPORT
Legend:
Ⓐ Silt Sampling Location
▲ Background Radiation Monitoring Station
◘ Fallout Sampling Location
● Soil Sampling Location
0
1/4
1/2
3/4
1
Scale in Miles

Figure 1. Bettis Atomic Power Laboratory sampling stations

---

[2] Summarized from "Environmental Radioactivity at the Bettis Atomic Power Laboratory for the First Six Months of 1965," Semiannual Report PNRO-DEV-134, issued July 16, 1965.

**Table 1. Beta-gamma radiation, Bettis January–June 1965**

| Measurements | Average levels, mR/hr | | |
|---|---|---|---|
| | Station 1 | Station 3 | Station 4 |
| High weekly level | 0.044 | 0.060 | 0.394 |
| Low weekly level | 0.012 | 0.010 | 0.010 |
| Mean | 0.016 | 0.012 | 0.038 |

the second 6 months of 1964. The higher background radiation levels at station #4 are due to the proximity of the environmental monitoring detector to the C-area critical test facility.

### *Fallout*

Fallout samples are collected at three locations at the perimeter of the laboratory. Samples are collected over a period of 1 month in high-wall stainless-steel pots, and are analyzed for gross beta activity. The average monthly concentration of radioactive fallout for the first half of 1965 was 3.86 nCi/m². There was no significant change in fallout activity during this period as compared to the last 6 months of 1964.

### *Soil samples*

Soil samples were collected at the eight locations shown in figure 1. These samples are not analyzed routinely but are retained for future analysis to establish background levels.

### *Stream silt*

Stream silt samples were taken quarterly at the three locations shown in figure 1. The results of analysis of these samples are presented in table 2.

**Table 2. Radioactivity in stream silt, Bettis January–June 1965**

| Period | Location | pCi/g of silt | |
|---|---|---|---|
| | | Alpha | Beta-gamma |
| First quarter, 1965 | A | 19 | 14 |
| | B | 15 | 14 |
| | C | 41 | 220 |
| Average | | 25 | 83 |
| Second quarter, 1965 | A | 67 | 220 |
| | B | 12 | 17 |
| | C | 17 | 25 |
| Average | | 32 | 87 |

The average alpha concentration on the stream silt samples was approximately the same as the average alpha concentration for these locations during the second six months of 1964. The average beta-gamma concentration is significantly increased over the average for the second 6 months of 1964. This was due to a higher concentration in the plant liquid effluent being discharged at location A. Beta-gamma results for the first quarter from location C are considered to be in error since the liquid effluent concentration during this period was lower than the previous period.

Recent coverage in *Radiological Health Data:*

| Period | Issue |
|---|---|
| July 1961–June 1962 | April 1963 |
| July 1962–June 1963 | April 1964 |
| July 1963–December 1963 | November 1964 |
| January–June 1964 | April 1965 |
| July–December 1964 | October 1965 |

## 2. Feed Materials Production Center January–June 1965[3]

*National Lead Company*
*Fernald, Ohio*

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 2. Cincinnati and Hamilton—the larger nearby communities—are situated 20 and 10 miles, respectively, from the center. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium, and with fabricating the metal into fuel elements.

An environmental survey program of air and water sampling is maintained to check the effectiveness of dust collectors and waste treatment processes. Inspection of the data indicates that releases of radioactive materials to the environment are controlled as required by AEC and State of Ohio regulations.

---

[3] Summarized from "Feed Materials Production Center Environmental Monitoring Semi-Annual Report for the First Half of 1965" (NLCO-958).

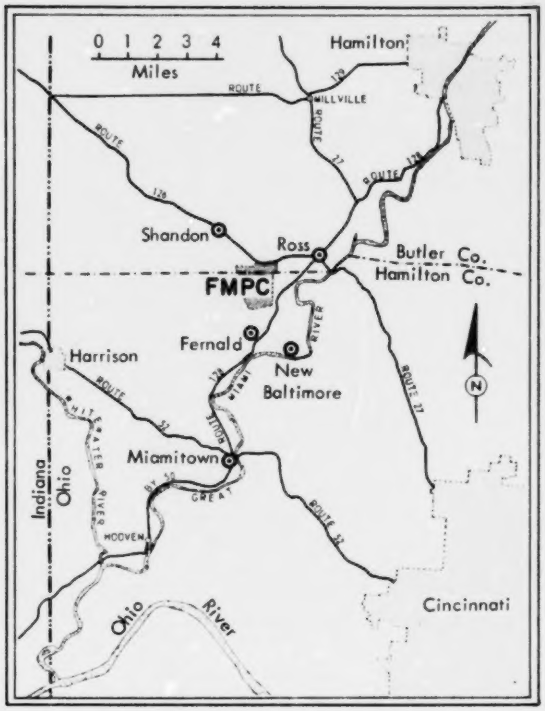
0 1 2 3 4
Miles
Hamilton
ROUTE
MILLVILLE
ROUTE 129
ROUTE 27
ROUTE 128
ROUTE 126
Shandon
Ross
Butler Co.
Hamilton Co.
FMPC
Fernald
New Baltimore
Harrison
RIVER
MIAMI
ROUTE 27
ROUTE 52
WHITEWATER RIVER
Miamitown
HOOVEN
GREAT
Indiana
Ohio
Ohio River
Cincinnati
N

Figure 2. Area map of Feed Materials Production Center

*Air monitoring*

FMPC uses dust collectors such as bag collectors, electrostatic precipitators, and scrubbing towers, which remove nearly all of the airborne particulates generated during the many plant operations. The environmental air sampling program provides an indication of the amount of material released into the atmosphere.

Onsite samples were taken at four permanent sampling stations located at the four corners of the production area shown in figure 3. Offsite samples were taken by a mobile unit operated at various distances and directions from the plant determined by local meteorological conditions on the day of sampling. The data for the offsite samples are averaged in groups according to distance from the production area. Concentrations of uranium and total activity of airborne particulates sampled at onsite and offsite locations are given in table 3.

**Table 3. Radioactivity levels of airborne particulates January–June 1965**

| Location | First half 1965 | | |
|---|---|---|---|
| | Number of samples | Uranium [a] (pCi/m³) | Total activity [b] (pCi/m³) |
| **Onsite** | | | |
| Southwest | 25 | 0.1 | 0.5 |
| Northwest | 25 | 0.1 | 0.3 |
| Northeast | 26 | 0.1 | 0.5 |
| Southeast | 26 | 0.1 | 0.3 |
| All onsite samples | 102 | 0.1 | 0.4 |
| **Offsite** | | | |
| 0–2 miles from FMPC | 26 | 0.3 | 1.5 |
| 2–4 miles from FMPC | 26 | <0.1 | 0.3 |
| 4–8 miles from FMPC | 22 | <0.1 | 0.3 |
| 8–12 miles from FMPC | 8 | <0.1 | 0.2 |
| All offsite samples | 82 | 0.16 | 0.7 |

[a] MPC, 2 pCi/m³

[b] MPC, 100 pCi/m³

*Water monitoring*

Continuous daily samples, collected from the combined sewer leading from the FMPC site to the Great Miami River, are analyzed for uranium and total activity. The combined sewage is composed of treated liquid effluent from the production plants, water treatment plants waste effluent, storm sewer discharge, and treated sanitary sewage. Using the data from the combined sewage samples and stream flow data for the Great Miami River, the FMPC contribution to radioactivity concentrations in the river may be calculated. To check the calculated results, weekly upstream and downstream spot samples are taken at the locations shown in figure 3.

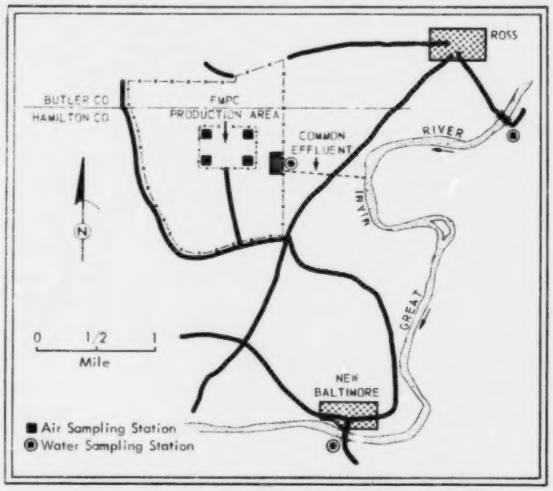
ROSS
BUTLER CO
HAMILTON CO
FMPC PRODUCTION AREA
COMMON EFFLUENT
RIVER
MIAMI
GREAT
N
0 1/2 1
Mile
NEW BALTIMORE
■ Air Sampling Station
◉ Water Sampling Station

Figure 3. Air and water sampling stations, Feed Materials Production Center

Table 4 presents the calculated and the spot check river concentrations. Since the calculated concentration represents only the contribution from FMPC, it should be compared with the difference of the upstream and downstream measurements.

**Table 4. Concentrations of uranium and total activity in the Great Miami River, Ohio, January–June 1965**

| Location | Method of determination | First half 1965 | | |
|---|---|---|---|---|
| | | Number of samples | Uranium [a] (pCi/liter) | Total activity [b] (pCi/liter) |
| Sewer outfall | Calculated from sewer concentrations and stream data (continuous sampling) | 181 | 2 | 20 |
| Upstream | Spot samples | 26 | 6 | 70 |
| Downstream | Spot samples | 30 | 9 | 60 |
| Difference | | | 3 | not applicable |

[a] MPC, 20,000 pCi/liter

[b] MPC, 3,000 pCi/liter

Recent coverage in *Radiological Health Data:*

| Period | Issue |
|---|---|
| July–December 1960 | June 1961 |
| January–June 1961 | December 1961 |
| July 1961–June 1962 | March 1963 |
| July 1962–December 1963 | May 1964 |
| January–June 1964 | April 1965 |
| July–December 1964 | October 1965 |

## 3. Knolls Atomic Power Laboratory January–June 1965[1]

*General Electric Company*
*Schenectady, New York*

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Atomic Energy Commission in the development of atomic power for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site, located as shown in figure 4. The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; and critical assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facility. Regular environmental monitoring activities are conducted to assure that Laboratory releases of radioactivity to the environment are in compliance with AEC standards. The data that follow indicate that Laboratory waste operations have complied with AEC requirements.

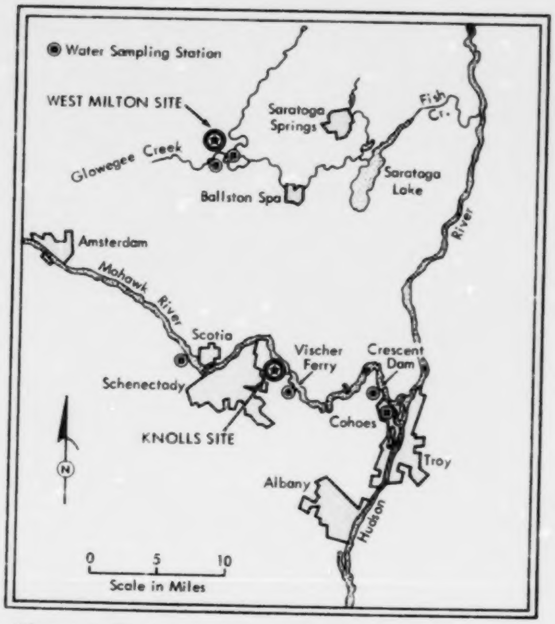

**Figure 4. Environmental monitoring locations, KAPL**

*Air monitoring*

Environmental airborne radioactivity is measured at two locations on the Knolls site, four locations at the West Milton site, and at the General Electric Company Research Laboratory (designated as offsite location) approximately 1 mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. Measurements of airborne radioactivity are made at least 48 hours after collection allowing the naturally occurring short-lived materials to decay. The results of the airborne radioactivity analyses are given in table 5.

---

[1] Summarized from "Knolls Atomic Power Laboratory Semiannual Environmental Monitoring Report, January–June 1965" (Volume 7, Number 1).

**Table 5. Airborne beta activity, KAPL January–June 1965**

| Sampling locations | Concentrations (pCi/m$^3$) |
|---|---|
| Knolls site | 0.24 |
| West Milton site | 0.25 |
| Offsite (Research Laboratory) | 0.24 |

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the perimeter of KAPL at both the West Milton and Knolls Sites. The perimeter survey of June 1965 showed normal background radiation levels for the geographic location.

### *Liquid waste monitoring*

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated according to the concentration of fission products in the collection tanks, and the flow of the river. A continuous proportional sample of the Knolls site combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium-90 is the principal component to be considered in control. The amounts and the radionuclide content of the combined sewer effluent discharged from the Knolls site have been summarized in table 6.

**Table 6. Radionuclide concentrations in the Knolls site waste effluent, January–June 1965**

| Radionuclides | Concentrations (pCi/liter) | AEC Standards (pCi/liter) |
|---|---|---|
| Strontium-89 | <7.3 | 3,000 |
| Strontium-90 | 240 | 300 |
| Ruthenium-106 | <7.3 | 10,000 |
| Iodine-131 | <7.3 | 300 |
| Cesium-137 | 410 | 20,000 |
| Cerium-praseodymium-144 | 58 | 10,000 |

A total of 195 millicuries of beta–gamma activity was discharged to the Mohawk River during the 6-month period at monthly average concentrations ranging from 140 to 1,300 pCi/liter.

Since Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of 3.55 millicuries was discharged at two points into Glowegee Creek during the 6-month period at monthly average concentrations ranging from 8 to 790 pCi/liter. Samples of the Glowegee Creek water are taken once a week at two locations, one at about 150 feet above the point where the S3G effluent enters the stream, and the other 2,640 feet below the S3G discharge or 1,500 feet below the D1G discharge.

Mohawk River water is sampled continuously at the point of discharge from the Knolls site; at the General Electric Company powerhouse 8 miles upstream from the site; at the Vischer Ferry powerhouse approximately 2 miles downstream; and at the City of Cohoes pumping station about 13 miles downstream. Results are given in table 7.

**Table 7. Gross beta-gamma activity in streams receiving effluents, January–June 1965**

| Streams and sampling locations | Concentrations (pCi/liter) |
|---|---|
| Mohawk River (Knolls site):[a] | |
| G.E. Powerhouse (upstream) | 6 |
| Vischer Ferry (downstream) | 7 |
| Cohoes (downstream) raw water | 8 |
| Cohoes (downstream) finished drinking water | 7 |
| Glowegee Creek (West Milton site):[a] | |
| Upstream | 12 |
| Downstream | 13 |

[a] MPC = 100 pCi/liter

Recent coverage in *Radiological Health Data:*

| Period | Issue |
|---|---|
| Third and fourth quarters 1960 | September 1961 |
| First and second quarters 1961 | March 1962 |
| July 1961–June 1962 | July 1963 |
| July 1962–December 1963 | June 1964 |
| January–June 1964 | April 1965 |
| July–December 1964 | October 1965 |

## 4. S1C Prototype Reactor Facility January–June 1965[5]

*Combustion Engineering, Inc.*
*Windsor, Connecticut*

The S1C Prototype is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in the operation of naval reactor power plants. Reactor power operations at the S1C prototype facility began in December 1959.

The low-level radioactive waste discharged intermittently from S1C Prototype operations consists mainly of water. Small quantities of airborne particulates in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially, all of the radioactive waste originates from the activation of minute amounts of impurities in corrosion products in the circulating water used as a reactor coolant. Small quantities of gaseous waste result from the activation of minute amounts of air dissolved in the coolant water.

All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations. Monitoring results which follow indicate that the facility has fully complied with the prescribed standards of the AEC.

### *Air monitoring*

Ventilation air from the submarine hull and the supporting facility at the prototype site may, at times, contain small amounts of airborne radioactive particulate or gaseous activities. This ventilation air is discharged to the environment through an exhaust stack. The ventilation air is continuously monitored for radioactivity by particulate and gaseous counters which control the discharge of the air. Alarms are sounded if the concentration approaches permissible limits. When these limits are exceeded, the exhaust air is discharged through a high-efficiency filter bank or the ventilation system is completely shut down and the hull sealed. In addition, air is sampled for particulates at several locations on and offsite. Table 8 presents the average gross beta activities in air.

**Table 8. Gross beta activity in air, S1C, January–June 1965**

| Sampling locations | Average concentrations (pCi/m³) |
|---|---|
| Stack and hull effluent | 59 |
| Onsite samples | 0.35 |
| Offsite samples | 0.44 |

### *Water monitoring*

Liquid wastes are collected in 5,000 gallon retention tanks. When a tank is full, it is sampled and analyzed for its radioactivity content. If the activity is below the allowable discharge limit, the tank contents are released into the industrial waste system. If the limit is exceeded, the contents are diluted below acceptable limits in a 25,000 gallon dilution tank and then released. Table 9 is a summary of the gross radioactivity released to the Farmington River.

**Table 9. Radioactivity in liquid wastes discharged into the Farmington River, S1C, January–June 1965**

| Activity | Quantity |
|---|---|
| Total beta activity (millicuries) | 11.6 |
| Average concentrations (pCi/liter) | |
| Gross beta | 3,500 |
| Cobalt-60 | 2,800 |
| Iron-59 | 72 |
| Manganese-54, cobalt-58 | 490 |

The Farmington River is sampled periodically at various locations as shown in figure 5 for determination of gross beta activity in river water and mud. Except for one sample taken at the storm drainage waste outlet (sampling location 3) which read 80 pCi/liter, all water samples were less than the detectable level of 10 pCi/liter. All mud samples contained less than the detectable levels of 10 pCi/g.

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[5] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report, January 1 to June 30, 1965" (CENRD-3163-RS-516).

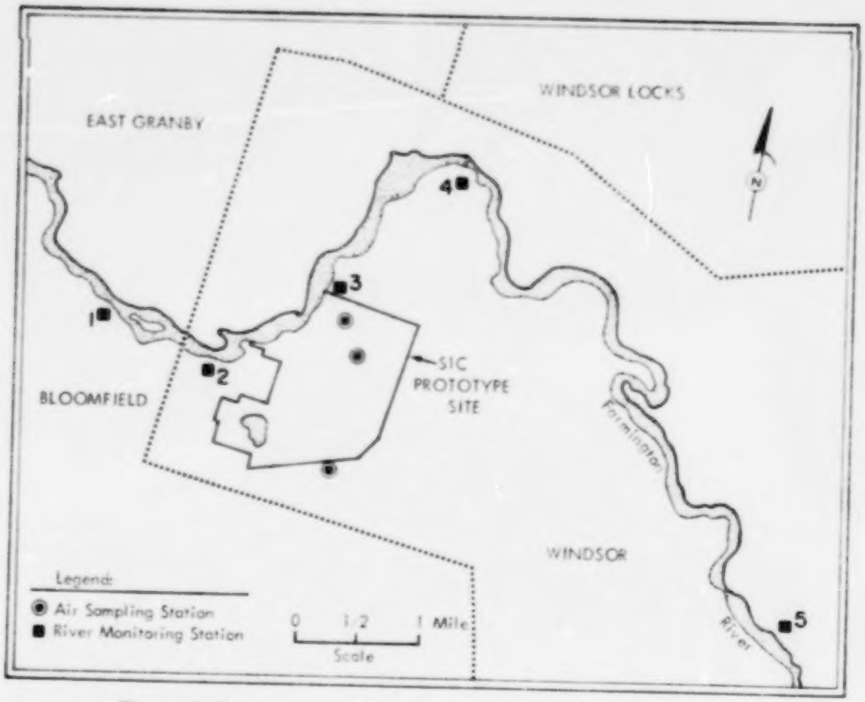
EAST GRANBY
WINDSOR LOCKS
N
4
3
1
2
S1C PROTOTYPE SITE
BLOOMFIELD
Farmington River
WINDSOR
5
Legend:
● Air Sampling Station
■ River Monitoring Station
0 1/2 1 Mile
Scale

Figure 5. Environmental monitoring locations, S1C Prototype site

Recent coverage in *Radiological Health Data:*

| Period | Issue |
|---|---|
| January–June 1961 | March 1962 |
| July 1961–June 1962 | July 1963 |
| July 1962–December 1963 | June 1964 |
| January–June 1964 | April 1965 |
| July–December 1964 | October 1965 |

# Section V. Technical Notes

## REPORTED NUCLEAR DETONATIONS, MARCH 1966

During March 1966, the Atomic Energy Commission announced five U.S. nuclear tests, one of which was part of the "Plowshare" Program for developing peaceful uses of nuclear explosives. The Commission also announced that on March 20, 1966, the United States recorded seismic signals from the Soviet nuclear testing area in the semipalatinsk region. These seismic signals were equivalent to those of a nuclear test in the low-intermediate to intermediate yield range.

A summary of the announced information on the U.S. tests is presented below.

| Date | Testing area | Type of test | Yield [a] |
|---|---|---|---|
| March 5 | Nevada test site | Underground | Low |
| 7 | Nevada test site | Underground | Low |
| 12 | Nevada test site | Underground | Low |
| 18 | Nevada test site | Underground | Low-intermediate |
| 21 | Nevada test site | Underground (Plowshare) | Low |

[a] Low yield is defined as equivalent to the force of less than 20 kilotons of TNT; low-intermediate yield means an equivalent explosive force in the range of 20 to 200 kilotons of TNT; intermediate yield is equivalent to 200 kilotons to 1 megaton of TNT.

# RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 5 May 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

*Radiological Health Data and Reports*, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

## CONTENTS

### REPORTS

Page

Disposal of Radioactive Wastes from U.S. Naval Nuclear-Powered Ships and Their Support Facilities ........ 257
*J. W. Vaughan* and *M. E. Miles*

The Galveston Environmental Surveillance Program, 1965.. 263
*D. H. Flora* and *M. C. Wukasch*

### DATA

SECTION I. MILK AND FOOD ........ 269

National and International Milk Surveillance ........ 270
(including list of other programs previously reported)

1. Pasteurized Milk Network, January 1966, *PHS* ...... 270
2. Canadian Milk Network, January 1966 ........ 273
3. Pan American Milk Sampling Program, January 1966, *PAHO* and *PHS* ........ 274

State Milk Surveillance Activities (including list of other State programs previously reported) ........ 275

1. Connecticut Milk Network, October–December and Annual Summary 1965 ........ 275
2. Indiana Milk Network, October–December and Annual Summary 1965 ........ 277
3. Michigan Milk Network, October–December and Annual Summary 1965 ........ 278
4. Minnesota Milk Network, July–December and Annual Summary 1965 ........ 281
5. New York Milk Network, July–December and Annual Summary 1965 ........ 283

53

## CONTENTS—continued

Page

6. Pennsylvania Milk Network, October–December and Annual Summary 1965 ---- 286

Food and Diet Surveillance Activities ---- 288
(including list of programs previously reported)

1. Radionuclides in Institutional Diet Samples, July–September 1965, *PHS* ---- 288

SECTION II. WATER ---- 293
(including list of programs previously reported)

Gross Radioactivity in Surface Waters of the United States, November 1965, *FWPCA* ---- 294

Radioactivity in Washington Surface Water, July 1964–June 1965 ---- 296

SECTION III. AIR AND DEPOSITION ---- 301

Radioactivity in Airborne Particulates and Precipitation (including list of programs previously reported) ---- 301

1. Radiation Surveillance Network, January 1966, *PHS* ---- 302
2. Canadian Air and Precipitation Monitoring Program, January 1966 ---- 305
3. Pan American Air Sampling Program, January 1966, *PAHO* and *PHS* ---- 306
4. Fallout in the United States and Other Areas, January–June 1965, *AEC* ---- 307

SECTION IV. OTHER DATA ---- 311

Environmental Levels of Radioactivity at Atomic Energy Commission Installations ---- 311

1. Lawrence Radiation Laboratory, January–June 1965 ---- 311
2. Mound Laboratory, January–June 1965 ---- 314

SECTION V. TECHNICAL NOTES ---- 316

Reported Nuclear Detonations, April 1966 ---- 316

Synopses ---- 317

Symbols, Units, and Equivalents ---- Inside back cover

## RADIOLOGICAL HEALTH DATA AND REPORTS

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service Division of Radiological Health

# Reports

# DISPOSAL OF RADIOACTIVE WASTES FROM U.S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES

*J. W. Vaughan* and *M. E. Miles*[1]

SYNOPSIS—This report presents data on disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities and summarizes results of environmental monitoring performed to confirm adequacy of waste disposal limits and procedures. The waste disposal data presented show that the total long-lived radioactivity in liquid waste discharges associated with operation and maintenance of Naval nuclear-powered ships has been less than 2 curies per year in any harbor. Results of environmental surveys of harbor water and bottom sediment for gross radioactivity and for cobalt-60 have shown that (1) no increase in radioactivity above normal background levels has been detected in harbor water, (2) discharges of liquid wastes from U.S. naval nuclear-powered ships have not caused a measurable increase in the general external background radioactivity of the environment, and (3) low-level cobalt-60 radioactivity has been detected in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards where maintenance and overhaul of Naval nuclear-powered ships have been conducted over a period of several years.

This report confirms that procedures issued by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the health and safety of the general public. These Navy procedures, which have been reviewed and concurred in by the U.S. Public Health Service and the U.S. Atomic Energy Commission, contain discharge limits which are consistent with applicable recommendations of the Federal Radiation Council, U. S. Atomic Energy Commission, and the International Commission on Radiological Protection.

The radioactivity in wastes discussed in this report originates in the pressurized water reactors of U.S. Naval nuclear-powered ships. As of January 1966, there were 56 nuclear-powered submarines and 3 nuclear-powered surface ships in operation. In these shipboard reactors, pressurized water circulating through the reactor core picks up the heat of nuclear reaction. Reactor cooling water circulates through a closed piping system including heat exchangers which transfer the heat to water in a separate secondary steam system; the steam is then used as the source of power for the propulsion plant as well as for auxiliary machinery. Discharges from ships occur primarily when reactor coolant water expands as a result of heating a reactor plant to operating temperature; this coolant passes through a purification system ion-exchange resin bed prior to discharge.

Construction, maintenance, overhaul, and refueling of these nuclear propulsion plants involve various shipyards, submarine tenders, and submarine bases. Liquid wastes discharged at these support facilities result from operations such as draining shipboard reactor systems, decontaminating radioactively contaminated piping systems, and laundering anticontamination clothing worn by personnel. These facilities are equipped with processing systems to remove most of the radioactivity from liquid wastes prior to discharge into harbors.

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Discharge limits for the low-level radioactive liquid wastes from U.S. Naval nuclear-powered ships and their support facilities are consistent with applicable recommendations issued by the Federal Radiation Council, U.S. Atomic Energy Commission (AEC), National Council on Radiation Protection and Measurements (NCRP), International Commission on Radiological Protection (ICRP), and National Academy of Sciences—National Research Council (*1–5*). In consonance with these recommendations the policy of the U.S. Navy is to minimize the amounts of radioactivity discharged into harbors. To implement this policy, the Navy has issued standard instructions defining the radioactive waste disposal limits and procedures to be used by U.S. Naval nuclear-powered ships and their support facilities. These instructions have been reviewed and concurred in by the U.S. Public Health Service and the U.S. Atomic Energy Commission.

The principal source of radioactivity in liquid wastes is from trace amounts of corrosion and wear products from reactor plant metal surfaces. The most predominant long-lived radionuclide (i.e., half-life greater than 1 day) in these corrosion and wear products is cobalt–60, which has a 5.3 year half-life; cobalt–60 also has the lowest maximum permissible concentration value for water listed by the AEC, NCRP, and ICRP for these corrosion and wear radionuclides (*2–4*). Therefore, radioactive waste disposal is controlled by assuming that all the long-lived radioactivity is cobalt–60. Short-lived radionuclides decay rapidly and are therefore less limiting than long-lived radioactivity for waste disposal considerations.

Fission products produced by the fission process of the reactor are retained metallurgically bound within the fuel alloy. As a result, the total radioactivity attributed to long-lived fission product radionuclides strontium–90 and cesium–137 in discharges from U.S. Naval nuclear-powered ships and their support facilities has been less than 1 millicurie per year for all harbors combined.

Table 1 lists volumes of liquid and total amounts of long-lived radioactivity discharged into various U.S. harbors during the past 5 calendar years; included are data from U.S. Naval nuclear-powered ships and from supporting shipyards, tenders, and submarine bases. Locations listed in table 1 include operating bases and home ports which have been regularly visited by Naval nuclear-powered ships. The quantities of radioactivity listed in this table are reported as if the entire radioactivity consisted of cobalt–60, the predominant long-lived radionuclide.

Liquid waste discharges reported in table 1 vary with the amount of overhaul and maintenance work in progress at individual locations. In spite of a large increase in overhaul work in 1965, the total radioactivity discharged was kept to levels comparable with previous years by effecting improvements in waste processing techniques. The low amounts of radioactivity in table 1 discharged by each facility are comparable to amounts discharged into rivers by a number of other facilities in the United States involved in nuclear power programs where stringent waste disposal controls similar to those used by the Navy are enforced.

During maintenance and overhaul operations, solid low-level radioactive wastes consisting of contaminated rags, plastic bags, paper, and scrap materials are collected by nuclear-powered ships and their support facilities. Solid materials from ships are transferred to a shipyard or other shore facility for packaging and disposal. For ultimate disposal, solid radioactive wastes are shipped to AEC approved burial sites, since shipyards and shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. Table 2 summarizes total radioactivity and volumes of radioactive wastes disposed of in the past 5 years.

### *Environmental monitoring*

Environmental monitoring surveys for radioactivity are periodically performed in harbors where U.S. Naval nuclear-powered ships are built or overhauled and where these ships have

**Table 1. Radioactive liquid waste discharges to U.S. harbors from U.S. Naval nuclear-powered ships and their support facilities for 1961 through 1965**

| Location | 1961 | | 1962 | | 1963 | | 1964 | | 1965 | | 5-year total curies |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thousand gallons | Curies | Thousand gallons | Curies | Thousand gallons | Curies | Thousand gallons | Curies | Thousand gallons | Curies | |
| 1. Portsmouth, New Hampshire<br>Naval Shipyard | 39 | 0.01 | 1,344 | 0.07 | 112 | 0.03 | 407 | 0.13 | 204 | 0.24 | 0.48 |
| 2. Quincy, Massachusetts<br>Electric Boat Division | 59 | 0.01 | 22 | 0.05 | 104 | 0.09 | 0 | 0 | 0 | 0 | 0.15 |
| 3. Groton-New London, Connecticut<br>Electric Boat Division, State Pier, and Submarine Base | 166 | 0.87 | 110 | 1.40 | 101 | 1.69 | 201 | 1.93 | 828 | 1.29 | 7.18 |
| 4. Camden, New Jersey<br>New York Shipbuilding Corp. | 0 | 0 | 66 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 |
| 5. Newport News, Virginia<br>Newport News Shipbuilding | 445 | 0.18 | 460 | 0.18 | 21 | 0.01 | 965 | 0.24 | 3,360 | 1.70 | 2.31 |
| 6. Norfolk, Virginia<br>Naval Shipyard and Base | 0 | 0 | 0 | 0 | 300 | 0.07 | 337 | 0.61 | 1,146 | 0.44 | 1.17 |
| 7. Charleston, South Carolina<br>Naval Shipyard and Base | 11 | 0.01 | 31 | 0.01 | 246 | 0.14 | 294 | 0.36 | 717 | 0.67 | 1.19 |
| 8. Pascagoula, Mississippi<br>Ingalls Shipbuilding Corp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9. San Diego, California<br>Navy Piers, Ballast Point | 5 | 0.01 | 0 | 0 | 34 | 0.25 | 35 | 0.40 | 40 | 0.33 | 0.99 |
| 10. Vallejo, California<br>S.F. Bay Naval Shipyard | 14 | 0.02 | 100 | 0.93 | 65 | 0.55 | 63 | 0.62 | 128 | 0.21 | 2.33 |
| 11. Bremerton, Washington<br>Puget Sound Naval Shipyard | 0 | 0 | 0 | 0 | 1 | 0.02 | 0 | 0 | 196 | 0.01 | 0.03 |
| 12. Pearl Harbor, Hawaii<br>Naval Shipyard and Base | 25 | 0.10 | 258 | 0.72 | 594 | 0.92 | 405 | 0.98 | 548 | 0.48 | 3.20 |
| 13. Apra Harbor, Guam | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 69 | 0.01 | 0.01 |
| Totals | 764 | 1.21 | 2,391 | 3.37 | 1,578 | 3.77 | 2,707 | 5.27 | 7,236 | 5.38 | 19.05 |

Notes:

(1) U.S. harbors where shipyards and operating bases for nuclear-powered ships are located are included. Other U.S. harbors have had less than 20 thousand gallons and less than 0.1 curie discharged per year.

(2) Where discharges in one harbor for a year totaled less than 0.005 curies, "0" is reported in this table.

(3) Radioactivity data has been standardized to cobalt-60. Volumes are reported prior to dilution.

home ports or operating bases. These surveys are performed to verify the adequacy of liquid waste disposal procedures and limits.

Shipyards, tenders, and submarine bases have taken weekly samples of harbor water and bottom sediment in the vicinity of berths used by nuclear-powered ships, beginning in each harbor prior to operation of these ships. Radioactivity data from harbor water and sediment samples taken by individual facilities indicate that operation and maintenance of nuclear-powered ships have not caused significant changes in the gross radioactivity of harbor water or sediment. However, relatively large variations in gross radioactivity measured in environmental samples do occur from changes in natural and fallout sources. Because of these variations, monitoring for gross radioactivity in harbor water and sediment is not sufficient to detect small changes in environmental radioactivity which might be attributed to operation and maintenance of Naval nuclear-powered ships.

To monitor for these small changes in environmental radioactivity, specific analyses of water and sediment samples for cobalt–60 have been added to Navy monitoring programs in recent years. Cobalt–60 is a sensitive tracer to follow environmental distribution of radioactivity because it has the longest half-life and is the predominant long-lived radionuclide in liquid waste discharges; in addition, cobalt–60 has not been detected in significant concentrations in radioactivity from fallout or natural sources.

Therefore, starting in 1963, a bottom sedi-

57

**Table 2. Radioactive solid waste disposed of by facilities supporting U.S. Naval nuclear-powered ships for 1961 through 1965**

| Facility | 1961 | | 1962 | | 1963 | | 1964 | | 1965 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hundred cubic feet | Curies | Hundred cubic feet | Curies | Hundred cubic feet | Curies | Hundred cubic feet | Curies | Hundred cubic feet | Curies |
| 1. Portsmouth, New Hampshire Naval Shipyard | 4 | 0 | 80 | 0.5 | 15 | 0.5 | 80 | 2.6 | 150 | 2.6 |
| 2. Quincy, Massachusetts Electric Boat Division | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3. Groton-New London, Connecticut Electric Boat Division, Tender at State Pier, and Submarine Base | 138 | 39.1 | 85 | 1.5 | 102 | 1.1 | 99 | 2.3 | 155 | 353.0 |
| 4. Camden, New Jersey New York Shipbuilding Corp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5. Newport News, Virginia Newport News Shipbuilding | 1 | 0 | 10 | 0.1 | 8 | 0.3 | 22 | 1.8 | 198 | 28.0 |
| 6. Norfolk, Virginia Naval Shipyard and Tender | 0 | 2 | 0 | 0 | 3 | 0 | 5 | 0.5 | 33 | 1.6 |
| 7. Charleston, South Carolina Naval Shipyard and Tenders | 5 | 5.0 | 9 | 1.1 | 35 | 0.4 | 47 | 1.0 | 78 | 111.5 |
| 8. Pascagoula, Mississippi Ingalls Shipbuilding Corp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9. San Diego, California Tenders at Ballast Point | 0 | 0 | 0 | 0 | 2 | 0.1 | 7 | 7.5 | 3 | 0 |
| 10. Vallejo, California S.F. Bay Naval Shipyard | 12 | 4.3 | 52 | 6.0 | 35 | 19.0 | 9 | 0.3 | 47 | 9.4 |
| 11. Bremerton, Washington Puget Sound Naval Shipyard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0.1 |
| 12. Pearl Harbor, Hawaii Naval Shipyard and Base | 0 | 0 | 0 | 0 | 16 | 0.4 | 13 | 0.7 | 8 | 1.4 |
| Totals | 160 | 48.4 | 236 | 9.2 | 216 | 21.8 | 282 | 16.7 | 676 | 507.6 |

Notes:
(1) Where total radioactivity is less than 0.05 curies, "0" is reported in this table.
(2) This table also includes waste from tenders and nuclear powered ships.

ment sample taken in each harbor from the vicinity of nuclear-powered ship berths was analyzed for cobalt–60 to supplement the gross radioactivity measurements described above. This additional sampling was performed in cooperation with the U.S. Public Health Service (USPHS), and analyses were performed at their Southeastern Radiological Health Laboratory. Results of USPHS analyses for cobalt–60 in harbor bottom sediment samples taken from the vicinity of nuclear-powered ship berths are shown in table 3. Since each number in table 3 is the result of a single sample, more extensive sampling, discussed below, was deemed necessary to determine whether the isolated data points were representative of the surrounding harbor bottom sediment.

To obtain more representative data and to evaluate the cumulative effect of liquid waste discharges over the preceding years, extensive environmental surveys were performed commencing in July 1965. Cobalt–60 analyses were performed on 20 to 70 bottom sediment samples taken from each harbor where Naval nuclear-powered ships have been most frequently based or overhauled; these samples were taken from the top layer of sediment (approximately 1 inch thick) in the immediate vicinity of and away from berthing areas used by Naval nuclear-powered ships. Results of these July 1965 surveys, which involved a total of 345 samples, are summarized in table 4. These surveys show that the total amount of cobalt–60 observed in bottom sediment near a few piers is small compared to natural radioactivity present in harbors.

In conjunction with the bottom sediment sampling surveys reported in table 4, nearby shoreline areas uncovered at low tide were surveyed with sensitive beta-gamma detectors to determine if any of the discharged radioactivity had washed ashore. No shoreline

**Table 3. U.S. Public Health Service analyses of cobalt-60 in harbor bottom sediment in vicinity of berths used by U.S. Naval nuclear-powered ships**[a]

| Location | Picocuries of cobalt-60 per gram of ashed sediment | | | | | | |
|---|---|---|---|---|---|---|---|
| | Nov 1963 | July 1964 | Oct 1964 | Jan 1965 | Apr 1965 | July 1965 | Oct 1965 |
| 1. Portsmouth, New Hampshire Naval Shipyard | 1 | 6 | 4 | 5 | 0 | 2 | 0 |
| 2. Quincy, Massachusetts Electric Boat Division | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 3. Groton, Connecticut Electric Boat Division | 4 | 7 | 12 | 25 | 8 | 380 | 5 |
| 4. Camden, New Jersey New York Shipbuilding Corp | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5. Newport News, Virginia Newport News Shipbuilding | 22 | 0 | 0 | 0 | 0 | 2 | 0 |
| 6. Norfolk, Virginia Naval Shipyard | 0 | 0 | 0 | 0 | 0 | 0 | 14 |
| 7. Charleston, South Carolina Naval Shipyard | 1 | 2 | 0 | 3 | 0 | 5 | 0 |
| 8. Pascagoula, Mississippi Ingalls Shipbuilding Corp | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 9. San Diego, California Navy Piers, Ballast Point | No sample | 54 | 3 | 43 | 90 | 9 | 2 |
| 10. Vallejo, California S.F. Bay Naval Shipyard | 1 | 1 | 0 | 128 | 3 | 2 | 0 |
| 11. Bremerton, Washington Puget Sound Naval Shipyard | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12. Pearl Harbor, Hawaii Naval Shipyard | 22 | 33 | 270 | 63 | 75 | 37 | 40 |
| 13. Apra Harbor, Guam[b] | No sample | No sample | No sample | 0 | 0 | 0 | 0 |

[a] Each number is the result of a single sample and therefore may not be representative of the harbor bottom sediment around nuclear-powered ship berths. Results of more extensive sampling are in table 4. "0" indicates no cobalt-60 detected.

[b] Use of Apra Harbor, Guam as an operating base commenced January 1965.

radiation levels above the normal 0.01 to 0.03 millirem per hour background levels were detected in any of these locations.

In addition to the locations listed in table 4, environmental monitoring has been accomplished by U.S. Navy submarine tenders which serve as operating bases for U.S. Naval nuclear-powered submarines in Rota, Spain, and Holy Loch, Scotland. Data from these surveys have been exchanged with the host governments. Results of the surveys in the harbor at Rota, Spain, have not shown detectable cobalt-60 in harbor bottom sediment samples. In the Holy Loch, Scotland, anchorage more cobalt-60 radioactivity has been detected in harbor bottom sediment than was expected. Some slight increase in cobalt-60 radioactivity has also been found near the tender anchorage in Holy Loch on shoreline mud flat areas uncovered at low tide. However, there has been no increase of harbor water radioactivity in Holy Loch above normal background levels. Joint U.S. and British assessments of survey results have confirmed that radiation levels in the vicinity of the Holy Loch anchorage are still far below those which are at all likely to cause an individual to receive radiation exposure approaching limits for members of the general public.

Overall results of environmental surveys performed to date indicate the following:

(1) No increase in gross radioactivity above normal background levels has been detected in habor water where U.S. Naval nuclear-powered ships are based, overhauled, or constructed.

(2) Discharges of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase in the general external background radioactivity of the environment.

(3) Low level cobalt-60 radioactivity in harbor bottom sediment is detectable around a few

specific piers at operating bases and shipyards where nuclear-powered submarine maintenance and overhauls have been conducted over a period of several years. Cobalt-60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U.S. harbor is less than 1 curie of cobalt-60.

**Table 4. Summary of cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based or overhauled as surveyed in July 1965**

| Location | Total bottom area [a] with detectable cobalt-60 (square kilometers) [b] | Average cobalt-60 concentration in detectable area (picocuries cobalt-60/square centimeter) | Estimated total cobalt-60 on bottom (curies) |
|---|---|---|---|
| 1. Portsmouth, New Hampshire<br>Naval Shipyard | — | Not detectable | Not detectable |
| 2. Groton-New London, Connecticut<br>Electric Boat Division, State Pier, and Submarine Base | 0.1 | 190 | 0.19 |
| 3. Newport News, Virginia<br>Newport News Shipbuilding | — | Not detectable | Not detectable |
| 4. Norfolk, Virginia<br>Naval Base | — | Not detectable | Not detectable |
| 5. Charleston, South Carolina<br>Naval Shipyard and Base | — | Not detectable | Not detectable |
| 6. San Diego, California<br>Navy Piers at Ballast Point | 0.01 | 30 | 0.003 |
| 7. Vallejo, California<br>S.F. Bay Naval Shipyard | 0.01 | 10 | 0.001 |
| 8. Pearl Harbor, Hawaii<br>Naval Shipyard and Base | 0.3 | 10 | 0.03 |
| 9. Apra Harbor, Guam | — | Not detectable | Not detectable |

[a] All areas with detectable cobalt-60 were in immediate vicinity of piers used for berthing nuclear-powered ships.

[b] One square kilometer is approximately equal to 0.4 square miles; 1 picocurie = $10^{-12}$ curies.

## REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Federal Radiation Council memoranda, approved by President Eisenhower on May 13, 1960, and by President Kennedy on September 20, 1961.

(*2*) U.S. ATOMIC ENERGY COMMISSION. Standards for protection against radiation. Code of Federal Regulations, Title 10, Part 20.

(*3*) NATIONAL COUNCIL OF RADIATION PROTECTION AND MEASUREMENTS. Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure. National Bureau of Standards Handbook 69 (June 1959).

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Report of Committee II on permissible dose for international radiation, 1959. Also ICRP Supplement 6 (1962); ICRP Publication 2 (1959).

(*5*) NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL. Radioactive waste disposal from nuclear-powered ships, Publication 658. National Academy of Sciences—National Research Council, Washington, D.C. (1959).

# THE GALVESTON ENVIRONMENTAL SURVEILLANCE PROGRAM, 1965

*David H. Flora* and *Martin C. Wukasch*[1]

SYNOPSIS—Environmental surveillance between March 10 and August 20, 1965, at the Galveston refueling and servicing site for the Nuclear Ship Savannah indicated no detectable radioactive contamination attributable to the ship's operations. Surveillance activities which have continued at this site since 1962, include air, rain, sea water, silt, shellfish (oysters), and milk sampling. During the Savannah's 1965 visit, almost all analytical results for environmental samples were close to or below detectable limits, except for milk. Radioactivity trends in milk samples at this time closely followed the nationwide trend reported by the U.S. Public Health Service.

With the selection of Todd Shipyards on Pelican Island, Galveston, Texas, as the refueling and servicing site for the Nuclear Ship Savannah, the Texas State Department of Health and the U.S. Public Health Service cooperatively initiated the Galveston Environmental Surveillance Program. The program was begun in June 1962, some 6 months prior to the first arrival of the ship at the Pelican Island site, and has continued subsequently.

Previous reports have been distributed covering the first and second years of the sampling program.[2] These reports included the sampling schedule, type of samples collected, location of sampling stations, and results of the analyses of samples collected during that time. This report is for the purpose of providing essentially the same information for that portion of 1965 when the ship was in Galveston Harbor. The N.S. Savannah arrived in Galveston Harbor, March 10, 1965, and after a short period on public exhibition was docked at Todd Shipyards for repairs and modification until departure August 20, 1965.

### *Sample collection and analyses*

Air samples were collected three times a week. Sample station locations are shown in figure 1. The schedule of sample collection for the period is shown in table 1. The high-volume air samplers operate intermittently on an hour-on hour-off basis.

Seawater is collected by means of an intermittently operated peristaltic pump on an hour-on, 5-hour-off basis: i.e., 4 hourly samples are collected each day. The samples are accumulated in this manner for 2 weeks. At the end of this period, 4 liters of the composited sample are submitted to the laboratory for analysis.

Silt samples were collected from the bottom of the Galveston Channel at stations 10 and 11, by means of a spring-activated, hand-operated silt dredge. Samples were collected immediately prior to the N.S. Savannah's arrival, and again after its departure. Samples in the amount of 4 liters each were submitted to the laboratory for analysis.

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[1] Mr. Flora is supervisor, Surveillance Activities, and Mr. Wukasch is chief, Radiation Control Program, Division of Occupational Health and Radiation Control, Texas State Department of Health, Austin, Texas.

[2] Copies of earlier reports are available on request from the Texas State Department of Health.

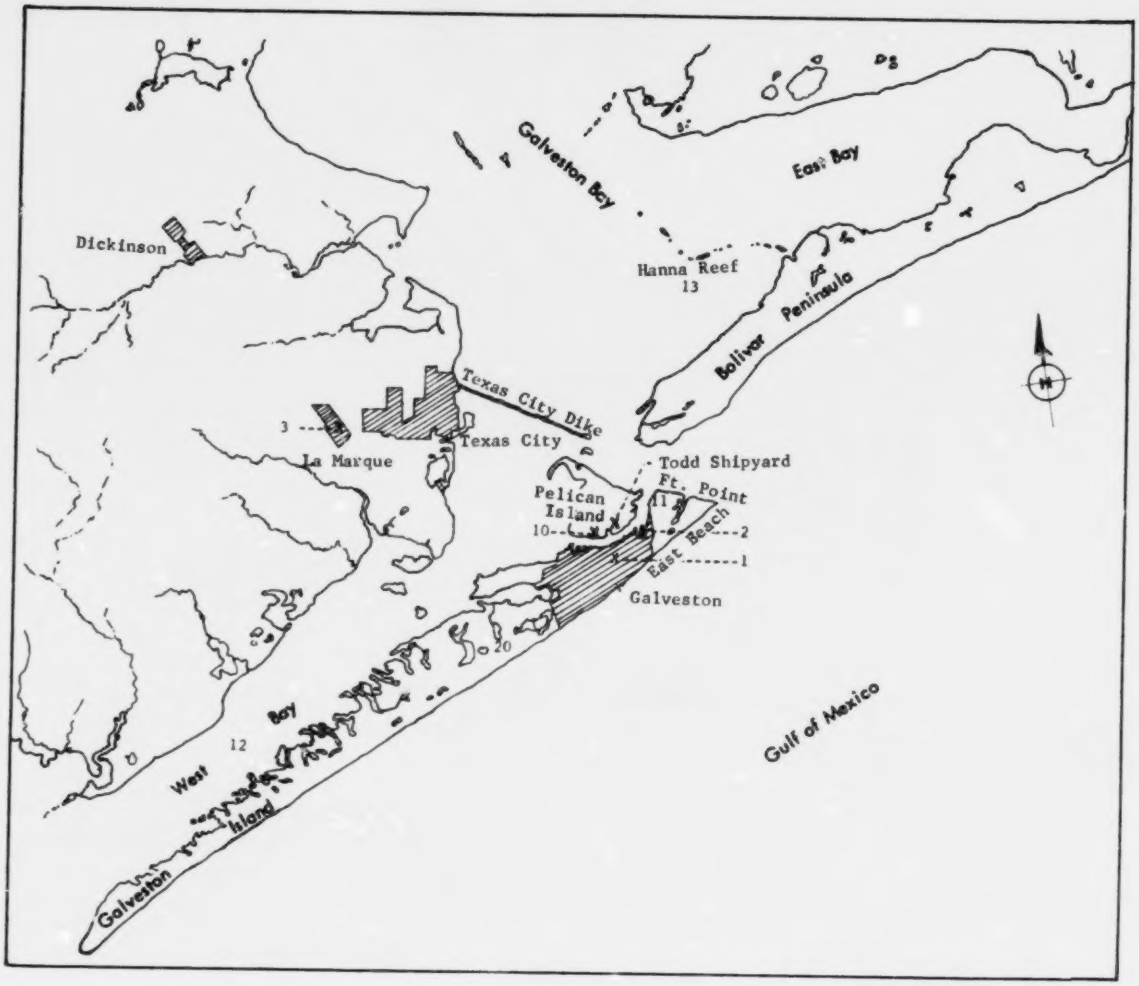
Galveston Bay
East Bay
Dickinson
Hanna Reef
13
Bolivar Peninsula
N
Texas City Dike
3
Texas City
La Marque
Todd Shipyard
Ft. Point
Pelican Island
11
10
2
East Beach
1
Galveston
20
Gulf of Mexico
Bay
12
West
Galveston Island

**Figure 1. Sampling station locations**

Four liters of raw milk were collected monthly from a dairy located on Galveston Island on a reimbursable basis.

All samples collected were analyzed by the Texas State Health Department Laboratory in Austin, Texas. The types of analysis performed are listed in table 2.

The analytical results of environmental samples collected in the Galveston vicinity are presented below.

*Air radioactivity*

Air samples were collected with a high-volume sampler located on the roof of the Galveston City Hall. Gross beta radioactivity in these air samples is listed in table 3, and monthly averages are shown graphically in figure 2.

Wide fluctuations of radioactivity in air occurred during the first year's operation as reported in the previous report. This was

**Table 1. Schedule of sample collection**

| Station number | Location | Sample type | Sample collected during report period |
|---|---|---|---|
| 1 | Galveston City Hall | Air | Yes |
| 2 | Ferry Landing | Air | No |
| 3 | Galveston County Health Department Building, La Marque | Air | No |
| 1 | Galveston | Rain | Yes |
| 10 | U.S. Naval Reserve Pier | Seawater | Yes |
| 11 | U.S. Corps of Engineers Pier | Seawater | Yes |
| 10 | Galveston Channel | Silt | Yes |
| 11 | Galveston Channel | Silt | Yes |
| 12 | West Bay | Silt | No |
| 13 | Hanna Reef, East Bay | Oysters | No |
| 20 | Shaper's Dairy, Galveston | Milk | Yes |

**Table 2. Analytical and sampling activities of Galveston 1965 program**

| Type of radioactivity analysis | Type of sample |
|---|---|
| Gross beta | All except milk |
| Gross alpha | All except milk and air |
| Gamma scan | All except air |
| Chemical separations: carbonate and basic sulfides | Seawater |
| Strontium-89 and strontium-90 | Milk |

**Table 3. Radioactivity in air at Galveston City Hall**

| Date filter removed, 1965 | Gross beta (pCi/$m^3$) | Date filter removed, 1965 | Gross beta (pCi/$m^3$) |
|---|---|---|---|
| March 1 | 0.2 | June 7 | 0.8 |
| 3 | 0.2 | 9 | 0.6 |
| 5 | 0.3 | 11 | 0.5 |
| 8 | 0.5 | 14 | 0.5 |
| 10 | 0.5 | 16 | 0.1 |
| 12 | 0.3 | 18 | 0.3 |
| 15 | 0.3 | 21 | 0.3 |
| 17 | 0.4 | 23 | 0.8 |
| 19 | 0.3 | 25 | 0.2 |
| 24 | 0.4 | 28 | 0.2 |
| 26 | 0.1 | 30 | 0.1 |
| 29 | 0.2 | July 2 | 0.2 |
| 30 | 0.1 | 6 | 0.2 |
| April 2 | 0.1 | 9 | 0.1 |
| 5 | 0.2 | 12 | 0.1 |
| 7 | 0.4 | 14 | 0.1 |
| 9 | 0.3 | 16 | 0.1 |
| 12 | 0.3 | 19 | 0.1 |
| 14 | 0.3 | 21 | 0.2 |
| 16 | 0.4 | 23 | 0.2 |
| 19 | 0.3 | 26 | 0.2 |
| 21 | 0.5 | 28 | 0.1 |
| 23 | 0.3 | 30 | 0.1 |
| 26 | 0.3 | Aug 2 | 0.1 |
| May 3 | 0.4 | 4 | 0.1 |
| 7 | 0.3 | 6 | NS |
| 10 | 0.3 | 9 | NS |
| 14 | 0.3 | 11 | NS |
| 17 | 0.3 | 13 | NS |
| 19 | 0.4 | 16 | 0.1 |
| ? | 0.1 | 18 | 0.1 |
| 24 | 0.3 | 20 | 0.1 |
| 26 | 0.3 | 23 | 0.1 |

?, Date uncertain.
NS, no sample.

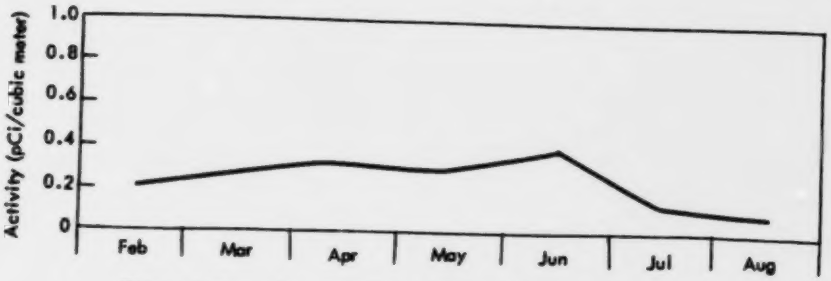

Figure 2. Gross beta activity in air, Station 1, Galveston City Hall, February–August 1965

shown to be the result of fallout from nuclear weapons testing. However, during the time period covered in this report, only those fluctuations associated with normal background were observed.

*Seawater radioactivity*

The high dissolved solids content of seawater makes the standard gross beta and gross alpha determinations impractical from an analytical standpoint; therefore chemical fractionation of samples has been performed. The carbonate and basic sulfides fractions have been used in this study as indicators of seawater contamination. The activity of the carbonate fraction is indicative of alkaline earths content. Strontium and radium are part of this chemical family.

63

The activity of the basic sulfides fraction is indicative of the transitional elements and the rare earths. These include cobalt, zinc, iron, nickel, ruthenium, yttrium, zirconium, and cerium. Interference due to sodium solids, cesium, and potassium-40 activity is eliminated by these two processes.

Seawater samples were collected from two locations during this report period. Results of the analyses are given in tables 4 and 5. There was little, if any, change in the levels of radioactivity found during previous surveillance operation. Most samples were below the limit of detectability (1.0 pCi/liter). The highest concentration in the carbonate fraction was 2 pCi/liter, and basic sulfides fraction, 12 pCi/liter. These low levels can be attributed to natural background.

### *Milk radioactivity*

The concentration of various radionuclides in the raw milk samples is listed in table 6 and shown graphically in figure 3. It should be noted that the short half-life radionuclides, iodine-131 and barium-140, were not detected in any of the samples. The longer half-life radionuclides, strontium-90 and cesium-137, are shown to be decreasing during the report period. This pattern of fluctuating strontium-90 and cesium-137 with the absence of iodine-131 and barium-140 corresponds with that found all over the United States by the Public Health Service through its Pasteurized Milk Surveillance Network. Therefore, these radionuclide concentrations in milk from Galveston can be attributed entirely to fallout from nuclear weapons testing.

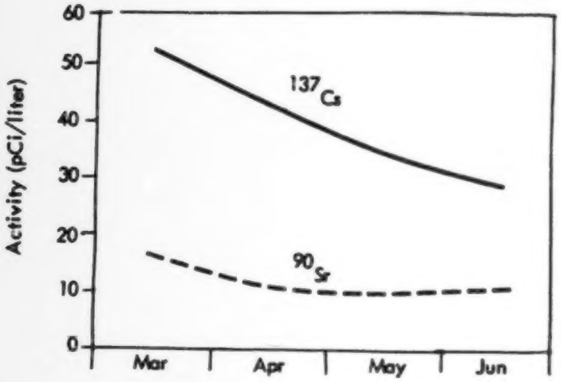

Figure 3. Radioactivity in milk, Station 20
Galveston, March-June 1965

Table 4. Radioactivity in seawater, Station 10

| Date collected 1965 | | Suspended solids | | Dissolved solids | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Gross alpha (pCi/liter) | Gross beta (pCi/liter) | Gross alpha (pCi/liter) | | Gross beta (pCi/liter) | | Gamma scan (pCi/liter) |
| | | | | C [a] | BS [b] | C [a] | BS [b] | |
| Feb | 23 | NA | NA | <1 | <1 | <1 | 4 | (c) |
| March | 16 | NA | NA | <1 | <1 | 1 | 3 | (c) |
| | 23 | NA | NA | <1 | <1 | 1 | 3 | (c) |
| | 30 | <1 | <1 | <1 | <1 | 1 | 6 | (c) |
| April | 6 | <1 | 2 | <1 | <1 | 1 | 12 | (c) |
| | 13 | <1 | <1 | <1 | <1 | 1 | 4 | (c) |
| | 20 | <1 | 2 | <1 | <1 | 2 | 1 | (c) |
| May | 4 | <1 | 2 | <1 | <1 | 1 | 2 | (c) |
| | 11 | <1 | 1 | <1 | <1 | 2 | 2 | (c) |
| | 18 | <1 | 6 | <1 | 1 | 2 | 1 | (c) |
| June | 1 | 1 | 3 | 1 | <1 | 2 | 1 | (c) |
| | 15 | <1 | 2 | 1 | <1 | 2 | 3 | (c) |
| | 30 | <1 | 4 | <1 | <1 | 1 | 3 | (c) |

[a] C, carbonate
[b] BS, basic sulfide
[c] Below quantitative levels except potassium-40.
NA, no analysis

Table 5. Radioactivity in seawater, Station 11

| Date collected 1965 | | Suspended solids | | Dissolved solids | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Gross alpha (pCi/liter) | Gross beta (pCi/liter) | Gross alpha (pCi/liter) | | Gross beta (pCi/liter) | | Gamma scan (pCi/liter) |
| | | | | C [a] | BS [b] | C [a] | BS [b] | |
| Feb | 23 | NA | NA | <1 | <1 | 1 | 2 | (c) |
| March | 16 | NA | NA | <1 | <1 | <1 | 2 | (c) |
| | 23 | <1 | <1 | <1 | 1 | <1 | 5 | (c) |
| | 30 | NA | NA | <1 | 1 | 1 | 2 | (c) |
| April | 6 | <1 | 2 | <1 | <1 | 1 | 9 | (c) |
| | 13 | <1 | 2 | <1 | <1 | 1 | 2 | (c) |
| | 20 | 1 | 1 | 1 | 1 | 2 | 2 | (c) |
| May | 4 | <1 | 2 | <1 | <1 | 1 | 2 | (c) |
| | 11 | 1 | 2 | <1 | <1 | 2 | 2 | (c) |
| | 18 | <1 | 5 | <1 | <1 | 1 | 5 | (c) |
| June | 1 | <1 | 2 | <2 | <1 | 2 | 2 | (c) |
| | 15 | <1 | 2 | 1 | <1 | 2 | 3 | (c) |
| | 29 | <1 | 1 | <1 | <1 | 2 | 1 | (c) |

[a] C, carbonate
[b] BS, basic sulfide
[c] Below quantitative levels except potassium-40.
NA, no analysis

### *Discussion*

The results reported herein are almost entirely free of large fluctuations. This was due not only to the absence of significant contamination from the Nuclear Ship Savannah operations, but also because no atmospheric nuclear

**Table 6. Radioactivity in silt, stations 10 and 11** [a]

| Station number and date | Gross beta (pCi/g) | Gross alpha (pCi/g) |
|---|---|---|
| Station 10 | | |
| 2/23/65 | 23 | 6 |
| 8/30/65 | 30 | 12 |
| Station 11 | | |
| 2/23/65 | 18 | 6 |
| 8/30/65 | 20 | 5 |

[a] Results of gamma scans gave no peaks other than those attributable to naturally occurring radionuclides.

**Table 7. Radioactivity in milk, Station 20**

| Date collected 1965 | Radionuclide concentrations, pCi/liter | | | |
|---|---|---|---|---|
| | Iodine-131 | Barium-140 | Cesium-137 | Strontium-90 |
| March 10 | [a] <10 | [a] <10 | 50 | 16 |
| 16 | <10 | <10 | 60 | 18 |
| 23 | <10 | <10 | 45 | 18 |
| 30 | <10 | <10 | 55 | 15 |
| April 6 | <10 | <10 | 50 | 15 |
| 13 | <10 | <10 | 45 | 13 |
| 20 | <10 | <10 | 35 | 9 |
| May 4 | <10 | <10 | 40 | 9 |
| 11 | <10 | <10 | 30 | 10 |
| 18 | <10 | <10 | 35 | 12 |
| June 2 | <10 | <10 | 35 | 13 |
| 15 | <10 | <10 | 30 | 11 |
| 30 | <10 | <10 | 25 | 8 |

[a] Minimum detectable level 10 pCi/liter ($2\sigma$ analytical error)

weapons testing occurred during this report period. With the exception of the milk samples, almost all results were shown to be below the detectable limits or just above that limit. As was discussed earlier, the milk radioactivity trends followed closely the nationwide trend as shown by the Public Health Service.

The absence of significant findings during this report period is indicative of the ability of ships using nuclear power to operate without undue risk to the public.

### *Conclusions*

As the result of the 1965 operation of the Galveston Environmental Surveillance Program, it has been shown that no detectable radioactive contamination occurred in the Galveston-Pelican Island area due to the operations of the Nuclear Ship Savannah. The low levels of radioactivity detected in the various environmental samples are attributed to naturally occurring radionuclides and long-life mixed fission products from nuclear weapons testing.

### REFERENCE

(*1*) PORTER, C. R., R. J. AUGUSTINE, J. M. MATUSEK, JR., and M. W. CARTER. Procedures for determination of stable elements and radionuclides in environmental samples. Public Health Service Publication No. 999–RH–10 (January 1965).

# Data

## Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analysis of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1,2*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the International Commission on Radiological Protection (*4, 5*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Printing Office, Washington, D.C. 20402 (May 13, 1960).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press (1959).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press (1965).

# NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

| Program | Period reported | Last presented |
|---|---|---|
| Radiostrontium in milk, HASL | April–June 1965 | March 1966 |
| United Kingdom milk | January 1961–April 1962 | October 1962 |

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## 1. Pasteurized Milk Network
## January 1966

*Division of Radiological Health*
*and Division of Environmental Engineering*
*and Food Protection, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) was designated to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 *Radiological Health Data.*

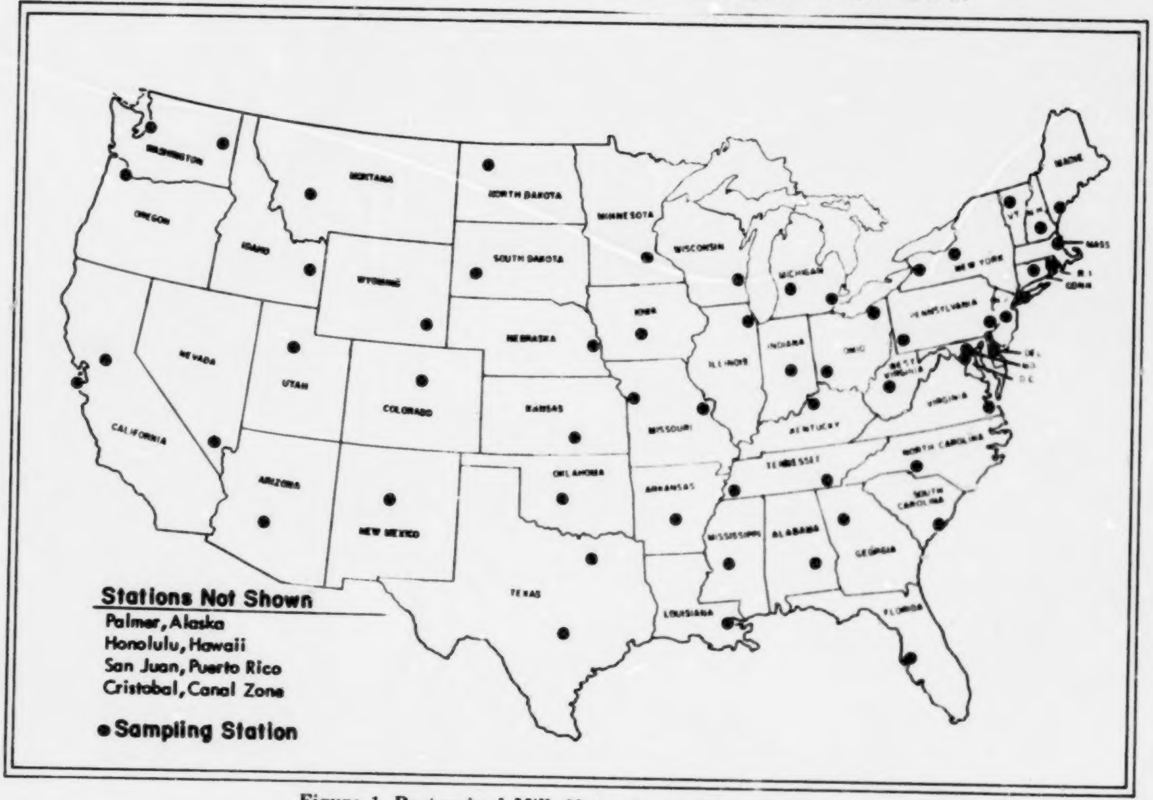
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Cristobal, Canal Zone
● Sampling Station
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
VT
N.H.
MAINE
MASS
R.I.
CONN
N.J.
DEL
MD
D.C.

Figure 1. Pasteurized Milk Network sampling stations

## Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the fourth quarter 1965 and January 1966 [a]

| Sampling location | | Calcium (g/liter) | | Strontium-89 (pCi/liter) | | Strontium-90 (pCi/liter) | | Cesium-137 (pCi/liter) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Fourth quarter 1965 | January 1966 | Fourth quarter 1965 | January 1966 | Fourth quarter 1965 | January 1966 | Fourth quarter 1965 | January 1966 |
| Ala: | Montgomery | 1.18 | 1.24 | <5 | <5 | 14 | 12 | 30 | 25 |
| Alaska: | Palmer | 1.30 | 1.25 | <5 | <5 | 15 | 13 | 55 | 45 |
| Ariz: | Phoenix | 1.25 | 1.25 | <5 | <5 | 4 | 4 | 15 | 15 |
| Ark: | Little Rock | 1.20 | 1.21 | <5 | <5 | 27 | 25 | 30 | 40 |
| Calif: | Sacramento | 1.27 | 1.30 | <5 | <5 | 4 | 5 | 15 | 20 |
| | San Francisco | 1.29 | 1.27 | <5 | <5 | 4 | 4 | 15 | 15 |
| C.Z: | Cristobal | 1.13 | 1.14 | <5 | <5 | 5 | 4 | 35 | 25 |
| Colo: | Denver | 1.28 | 1.28 | <5 | <5 | 12 | 12 | 25 | 25 |
| Conn: | Hartford | 1.12 | 1.13 | <5 | <5 | 12 | 11 | 40 | 40 |
| Del: | Wilmington | 1.15 | 1.21 | <5 | <5 | 14 | 13 | 35 | 45 |
| D.C: | Washington | 1.16 | 1.18 | <5 | <5 | 13 | 13 | 25 | 30 |
| Fla: | Tampa | 1.18 | 1.18 | <5 | <5 | 14 | 11 | 135 | 110 |
| Ga: | Atlanta | 1.17 | 1.19 | <5 | <5 | 19 | 19 | 45 | 40 |
| Hawaii: | Honolulu | 1.16 | 1.19 | <5 | <5 | 6 | 5 | 40 | 35 |
| Idaho: | Idaho Falls | 1.28 | 1.29 | <5 | <5 | 13 | 13 | 45 | 40 |
| Ill: | Chicago | 1.14 | 1.12 | <5 | <5 | 11 | 10 | 35 | 35 |
| Ind: | Indianapolis | 1.17 | 1.19 | <5 | <5 | 12 | 12 | 25 | 35 |
| Iowa: | Des Moines | 1.26 | 1.23 | <5 | <5 | 14 | 14 | 20 | 25 |
| Kans: | Wichita | 1.27 | 1.31 | <5 | <5 | 13 | 14 | 20 | 20 |
| Ky: | Louisville | 1.16 | 1.18 | <5 | <5 | 17 | 16 | 20 | 25 |
| La: | New Orleans | 1.22 | 1.26 | <5 | <5 | 30 | 28 | 40 | 40 |
| Maine: | Portland | 1.14 | 1.14 | <5 | <5 | 17 | 14 | 165 | 65 |
| Md: | Baltimore | 1.17 | 1.15 | <5 | <5 | 16 | 13 | 25 | 25 |
| Mass: | Boston | 1.15 | 1.16 | <5 | <5 | 16 | 14 | 60 | 60 |
| Mich: | Detroit | 1.12 | 1.13 | <5 | <5 | 11 | 10 | 30 | 35 |
| | Grand Rapids | 1.16 | 1.22 | <5 | <5 | 14 | 13 | 45 | 45 |
| Minn: | Minneapolis | 1.26 | 1.29 | <5 | <5 | 22 | 26 | 40 | 45 |
| Miss: | Jackson | 1.24 | 1.26 | <5 | <5 | 25 | 22 | 25 | 20 |
| Mo: | Kansas City | 1.22 | 1.23 | <5 | <5 | 16 | 16 | 20 | 20 |
| | St. Louis | 1.27 | 1.17 | <5 | <5 | 18 | 15 | 20 | 20 |
| Mont: | Helena | 1.31 | 1.28 | <5 | <5 | 15 | 14 | 45 | 60 |
| Nebr: | Omaha | 1.22 | 1.25 | <5 | <5 | 16 | 15 | 25 | 20 |
| Nev: | Las Vegas | 1.27 | 1.25 | <5 | <5 | 5 | 6 | 25 | 20 |
| N.H: | Manchester | 1.14 | 1.17 | <5 | <5 | 18 | 17 | 70 | 75 |
| N.J: | Trenton | 1.14 | 1.15 | <5 | <5 | 11 | 10 | 30 | 40 |
| N.Mex: | Albuquerque | 1.23 | 1.30 | <5 | <5 | 6 | 7 | 20 | 15 |
| N.Y: | Buffalo | 1.10 | 1.15 | <5 | <5 | 11 | 9 | 40 | 40 |
| | New York | 1.11 | 1.10 | <5 | <5 | 14 | 13 | 40 | 45 |
| | Syracuse | 1.10 | 1.14 | <5 | <5 | 12 | 10 | 35 | 35 |
| N.C: | Charlotte | 1.20 | 1.22 | <5 | <5 | 25 | 19 | 30 | 30 |
| N.Dak: | Minot | 1.27 | 1.28 | <5 | <5 | 30 | 32 | 40 | 45 |
| Ohio: | Cincinnati | 1.15 | 1.16 | <5 | <5 | 13 | 12 | 20 | 25 |
| | Cleveland | 1.14 | 1.16 | <5 | <5 | 13 | 13 | 25 | 35 |
| Okla: | Oklahoma City | 1.17 | 1.16 | <5 | <5 | 14 | 12 | 20 | 20 |
| Ore: | Portland | 1.27 | 1.28 | <5 | <5 | 12 | 13 | 40 | 40 |
| Pa: | Philadelphia | 1.12 | 1.16 | <5 | <5 | 12 | 11 | 30 | 35 |
| | Pittsburgh | 1.13 | 1.18 | <5 | <5 | 17 | 16 | 40 | 45 |
| P.R: | San Juan | 1.11 | 1.17 | <5 | <5 | 9 | 8 | 30 | 20 |
| R.I: | Providence | 1.14 | 1.17 | <5 | <5 | 15 | 13 | 45 | 45 |
| S.C: | Charleston | 1.19 | 1.20 | <5 | <5 | 25 | 22 | 55 | 45 |
| S.Dak: | Rapid City | 1.23 | 1.13 | <5 | <5 | 21 | 19 | 45 | 45 |
| Tenn: | Chattanooga | 1.25 | 1.22 | <5 | <5 | 22 | 20 | 30 | 25 |
| | Memphis | 1.18 | 1.19 | <5 | <5 | 18 | 17 | 20 | 20 |
| Tex: | Austin | 1.17 | 1.17 | <5 | <5 | 6 | 5 | 10 | 15 |
| | Dallas | 1.17 | 1.20 | <5 | <5 | 12 | 14 | 20 | 20 |
| Utah: | Salt Lake City | 1.38 | 1.39 | <5 | <5 | 12 | 12 | 40 | 35 |
| Vt: | Burlington | 1.12 | 1.18 | <5 | <5 | 14 | 15 | 50 | 55 |
| Va: | Norfolk | 1.18 | 1.15 | <5 | <5 | 16 | 16 | 25 | 25 |
| Wash: | Seattle | 1.30 | 1.27 | <5 | <5 | 16 | 15 | 45 | 40 |
| | Spokane | 1.31 | 1.36 | <5 | <5 | 16 | 14 | 45 | 35 |
| W.Va: | Charleston | 1.16 | 1.14 | <5 | <5 | 16 | 14 | 20 | 25 |
| Wis: | Milwaukee | 1.20 | 1.20 | <5 | <5 | 12 | 10 | 40 | 40 |
| Wyo: | Laramie | 1.29 | 1.20 | <5 | <5 | 16 | 15 | 45 | 30 |
| Network average | | 1.20 | 1.26 | <5 | <5 | 14.6 | 13.5 | 35 | 35 |

[a] Results of iodine-131 and barium-140 analyses below detectable levels.

**Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, January 1965, August–December 1965, and January 1966**

| Strontium-90 (pCi/liter) | Number of stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1965 | | | | | | 1966 |
| | Jan | Aug | Sept | Oct | Nov | Dec | Jan |
| Under 10 | 6 | 10 | 11 | 8 | 9 | 9 | 10 |
| 10–19 | 32 | 41 | 44 | 46 | 43 | 43 | 46 |
| 20–29 | 19 | 11 | 7 | 7 | 9 | 11 | 6 |
| 30–39 | 4 | 1 | 1 | 2 | 2 | 0 | 1 |
| 40–49 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50–59 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, January 1965, August–December 1965, and January 1966**

| Cesium-137 (pCi/liter) | Number of stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1965 | | | | | | 1966 |
| | Jan | Aug | Sept | Oct | Nov | Dec | Jan |
| Under 50 | 11 | 45 | 50 | 54 | 57 | 51 | 57 |
| 50–99 | 38 | 16 | 12 | 8 | 5 | 11 | 5 |
| 100–149 | 12 | 1 | 0 | 0 | 1 | 1 | 1 |
| 150–199 | 2 | 1 | 1 | 1 | 0 | 0 | 0 |

The results for January 1966 and fourth quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for August 1965 through January 1966, and January 1965. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

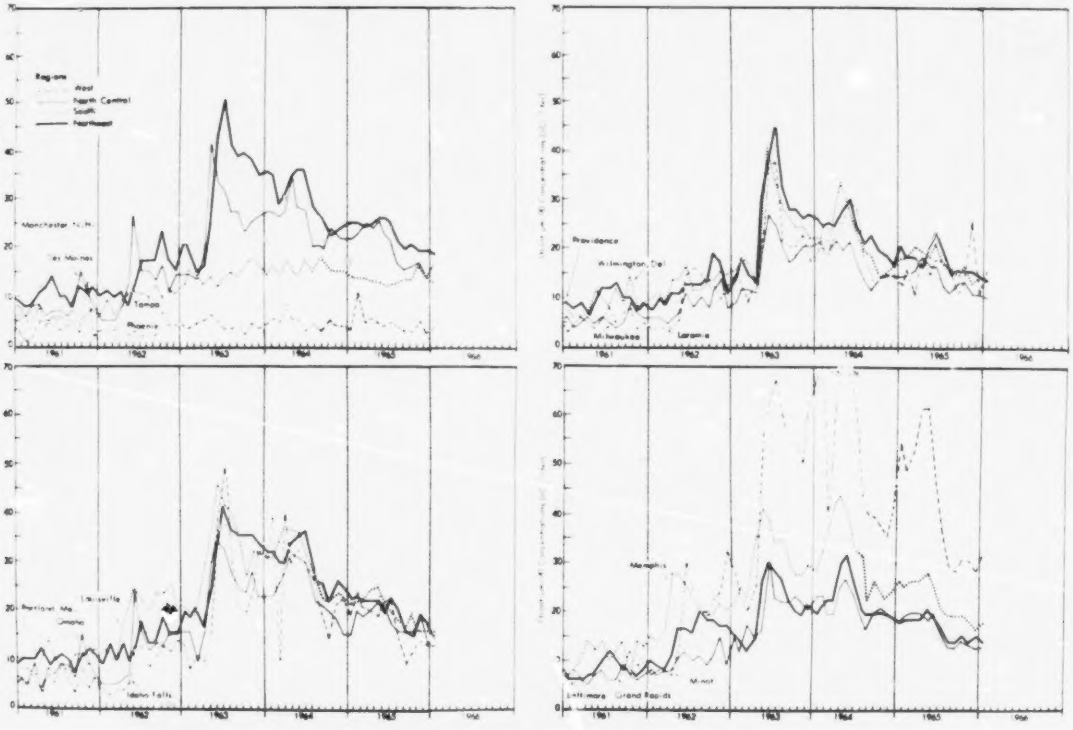

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961—January 1966

**Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, January 1965, August–December 1965, and January 1966**

| Strontium-90 (pCi/liter) | Number of stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1965 | | | | | | 1966 |
| | Jan | Aug | Sept | Oct | Nov | Dec | Jan |
| Under 10 | 6 | 10 | 11 | 8 | 9 | 9 | 10 |
| 10–19 | 32 | 41 | 44 | 46 | 43 | 43 | 46 |
| 20–29 | 19 | 11 | 7 | 7 | 9 | 11 | 6 |
| 30–39 | 4 | 1 | 1 | 2 | 2 | 0 | 1 |
| 40–49 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50–59 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, January 1965, August–December 1965, and January 1966**

| Cesium-137 (pCi/liter) | Number of stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1965 | | | | | | 1966 |
| | Jan | Aug | Sept | Oct | Nov | Dec | Jan |
| Under 50 | 11 | 45 | 50 | 54 | 57 | 51 | 57 |
| 50–99 | 38 | 16 | 12 | 8 | 5 | 11 | 5 |
| 100–149 | 12 | 1 | 0 | 0 | 1 | 1 | 1 |
| 150–199 | 2 | 1 | 1 | 1 | 0 | 0 | 0 |

The results for January 1966 and fourth quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for August 1965 through January 1966, and January 1965. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

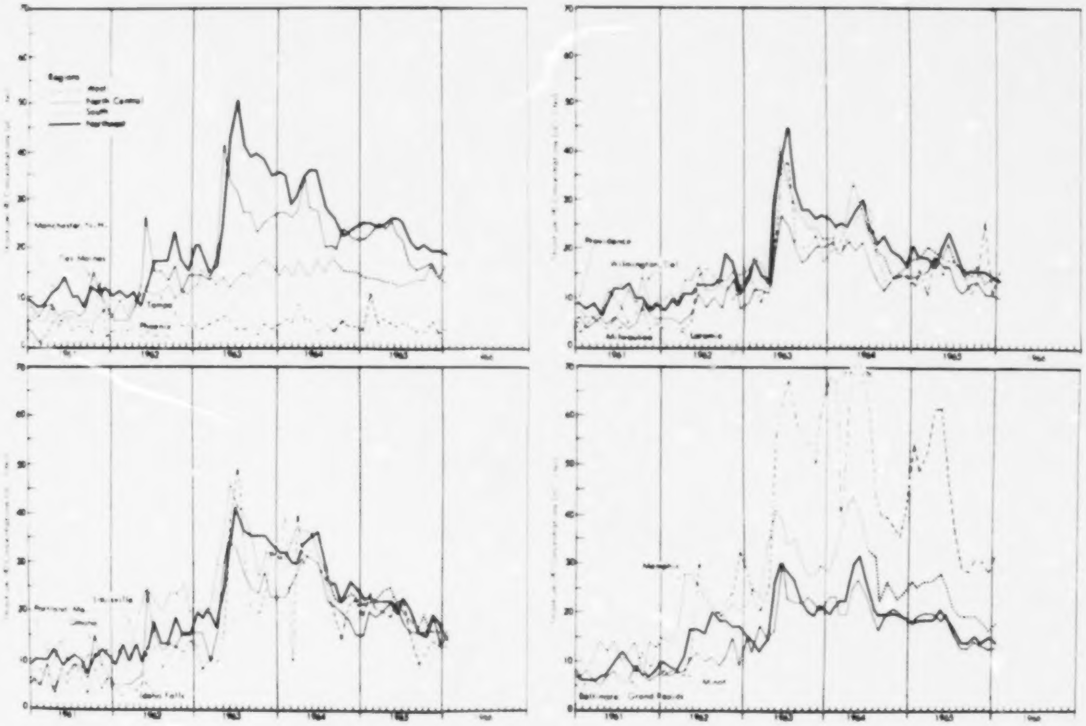

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961—January 1966

## 2. Canadian Milk Network
## January 1966[1]

*Radiation Protection Division*
*Department of National Health*
*and Welfare, Ottawa, Canada*

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (2).

The January 1966 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

**Table 4. Stable elements and radionuclides in Canadian whole milk, January 1966**

| Station | Calcium (g/liter) | Potassium (g/liter) | Strontium-90 (pCi/liter) | Cesium-137 (pCi/liter) |
|---|---|---|---|---|
| Calgary | 1.09 | 1.4 | 15.9 | 55 |
| Edmonton | 1.04 | 1.4 | 18.3 | 81 |
| Ft. William | 1.12 | 1.7 | 30.8 | 79 |
| Fredericton | 1.11 | 1.6 | 27.8 | 71 |
| Halifax | 1.03 | 1.5 | 21.1 | 68 |
| Montreal | 1.10 | 1.6 | 20.8 | 48 |
| Ottawa | 1.12 | 1.6 | 15.1 | 41 |
| Quebec | 1.06 | 1.6 | 27.2 | 86 |
| Regina | 1.03 | 1.4 | 15.6 | 32 |
| St. John's, Nfld | 1.05 | 1.5 | 28.5 | 89 |
| Saskatoon | 1.12 | 1.6 | 17.9 | 39 |
| Sault Ste. Marie | 1.11 | 1.6 | 26.7 | 75 |
| Toronto | 1.12 | 1.6 | 8.7 | 35 |
| Vancouver | 1.18 | 1.7 | 24.0 | 96 |
| Windsor | 1.11 | 1.6 | 8.8 | 27 |
| Winnipeg | 1.02 | 1.7 | 18.6 | 63 |
| Average | 1.09 | 1.6 | 20.4 | 62 |

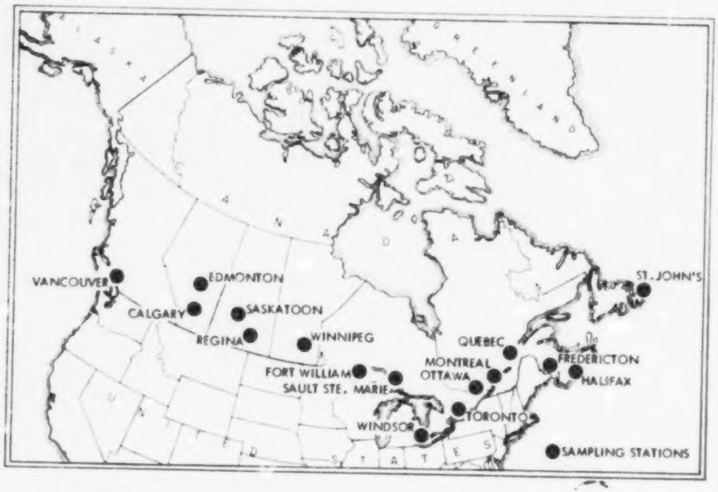

Figure 3. Canadian milk sampling stations

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[1] Prepared from February 1966 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

## 3. Pan American Milk Sampling Program January 1966

*Pan American Health Organization and Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*3*).

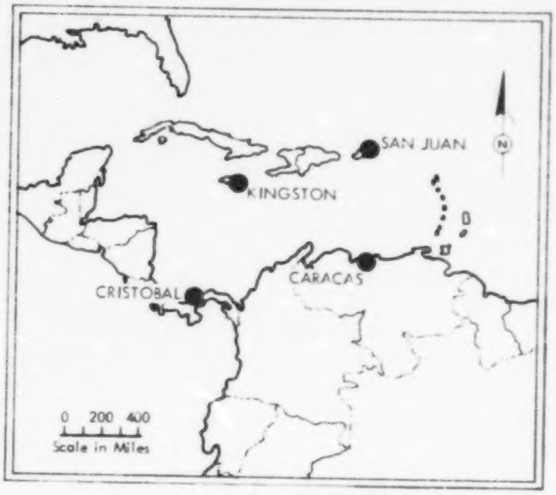

Figure 4. Pan American Milk Network sampling locations

Table 5 presents stable calcium and potassium, strontium–90, strontium–89, and cesium–137 monthly average concentrations. The monthly average iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

**Table 5. Stable element and radionuclide concentrations in PAHO milk January 1966**

| Sampling station | Calcium (g/liter) | Potassium (g/liter) | Strontium-89 (pCi/liter) | Strontium-90 (pCi/liter) | Cesium-137 (pCi/liter) |
|---|---|---|---|---|---|
| Canal Zone: | | | | | |
| Cristobal | 1.14 | 1.4 | <5 | 4 | 25 |
| Jamaica: | | | | | |
| Kingston | 1.11 | 1.34 | <5 | 11 | 115 |
| Mandeville | NS | NS | NS | NS | NS |
| Montego Bay | NS | NS | NS | NS | NS |
| Puerto Rico: | | | | | |
| San Juan | 1.17 | 1.5 | <5 | 8 | 20 |
| Venezuela: | | | | | |
| Caracas | 1.16 | 1.37 | <5 | 3 | 15 |

NS, no sample collected.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Milk surveillance, Pasteurized Milk Network, August 1965. Division of Radiological Health and Division of Environmental Engineering and Food Protection. Rad Health Data 6:677–681 (December 1965).

(*2*) RADIATION PROTECTION DIVISION, DEPARTMENT OF NATIONAL HEALTH AND WELFARE, OTTAWA, CANADA. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

71

## STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed to the level of comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein, while not inclusive, are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the networks presented herein, other State networks previously covered in *Radiological Health Data and Reports* include:

| State milk network | Period reported | Last presented |
|---|---|---|
| California | July–September 1965 | March 1966 |
| Colorado | October–December 1964 | April 1965 |
| Florida | July–December 1965 | March 1966 |
| Oklahoma | August–December 1965 | March 1966 |
| Oregon | July–September 1965 | March 1966 |
| Pennsylvania | July–September 1965 | February 1966 |
| Texas | April–December 1965 | March 1966 |
| Washington | July–September 1965 | March 1966 |

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### 1. Connecticut Milk Network October–December and Annual Summary 1965

*Connecticut State Department of Health*

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium–89 and strontium–90 since April 1960. In May 1962, the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 1). At the present time, a monthly sample representative of milk sold in the central area of the State is collected and analyzed for strontium–89, strontium–90, and gamma emitters. Concentrations of iodine–131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium–89 and strontium–90 are determined by chemical separation. Iodine–131 and other gamma emitters are determined by gamma-scintillation spectroscopy.

The monthly average concentrations of strontium–89, strontium–90, iodine–131, and cesium–137 in Connecticut pasteurized milk are presented in table 1. These results are presented graphically in figure 2. A summary of 1965 monthly average concentration is presented in table 2.

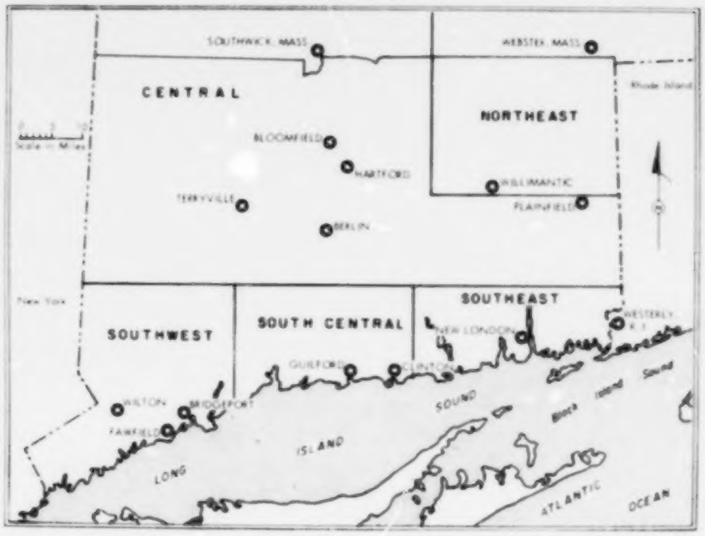
SOUTHWICK, MASS.
WEBSTER, MASS.
Rhode Island
CENTRAL
NORTHEAST
Scale in Miles
BLOOMFIELD
HARTFORD
WILLIMANTIC
PLAINFIELD
TERRYVILLE
BERLIN
New York
SOUTHEAST
WESTERLY R.I.
SOUTHWEST
SOUTH CENTRAL
NEW LONDON
GUILFORD
CLINTON
WILTON
BRIDGEPORT
FAIRFIELD
LONG
ISLAND
SOUND
Block Island Sound
ATLANTIC
OCEAN

Figure 1. Connecticut pasteurized milk sampling areas

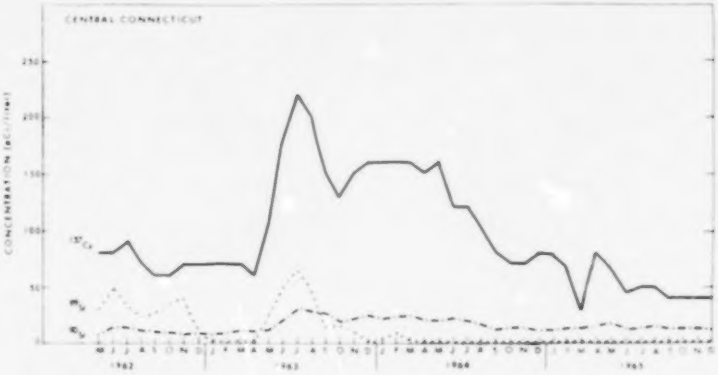

Figure 2. Radionuclide concentrations in Connecticut pasteurized milk, 1962–December 1965

Table 1. Radionuclide concentrations in central Connecticut milk, October–December 1965

| Month 1965 | Concentration, pCi/liter | | | |
|---|---|---|---|---|
| | Strontium-89 | Strontium-90 | Iodine-131 | Cesium-137 |
| October | ND | 13 | <10 | 40 |
| November | ND | 13 | <10 | 40 |
| December | ND | 12 | <10 | 40 |

ND, below detectable levels.

Recent coverage in *Radiolog...al Health Data and Reports*:

| Period | Issue |
|---|---|
| April 1960–December 1962 | May 1963 |
| Annual Summary 1963 | September 1964 |
| Annual Summary 1964 | May 1965 |
| January-March 1965 | August 1965 |
| April-September 1965 | February 1966 |

Table 2. Monthly average radionuclide concentrations in Connecticut milk, 1965

| Month 1965 | Concentration, pCi/liter | | | |
|---|---|---|---|---|
| | Strontium-89 | Strontium-90 | Iodine-131 | Cesium-137 |
| January | ND | 13 | <10 | 80 |
| February | ND | 15 | <10 | 70 |
| March | ND | 15 | <10 | 30 |
| April | ND | 15 | <10 | 80 |
| May | ND | 16 | <10 | 70 |
| June | ND | 13 | <10 | 40 |
| July | ND | 13 | <10 | 50 |
| August | ND | 14 | <10 | 50 |
| September | ND | 13 | <10 | 40 |
| October | ND | 13 | <10 | 40 |
| November | ND | 13 | <10 | 40 |
| December | ND | 12 | <10 | 40 |

ND, below detectable levels.

## 2. Indiana Milk Network October–December and Annual Summary 1965

*Bureau of Environmental Sanitation*
*Indiana State Board of Health*

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds: northeast, northwest, central, southeast, and southwest (figure 3). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are analyzed for strontium-89, strontium-90, cesium-137, iodine-131, and barium-140. Strontium-89 and strontium-90 analyses are performed monthly while cesium-137, iodine-131 and barium-140 analyses are performed weekly. When iodine-131 concentrations exceed 100 pCi liter, the sampling frequency is increased. Since August 1963, because of the continued low concentrations of short-lived radionuclides, the sampling frequency has been once a month for the northeast, southeast, and southwest milksheds.

Strontium-89 and strontium-90 concentrations in milk samples are determined by ion exchange separation (*1, 2*) while cesium-137, iodine-131, and barium-140 are determined by gamma-scintillation spectrometry (*3*).

The monthly radionuclide concentrations in Indiana pasteurized milk are presented by station in table 3 for October through December 1965. The monthly concentrations of iodine-131 and barium-140 remained below limits of detectability.

The monthly network average concentrations of strontium-89, strontium-90, and cesium-137 are presented graphically in figure 4. A summary of 1965 monthly average concentration is presented in table 4.

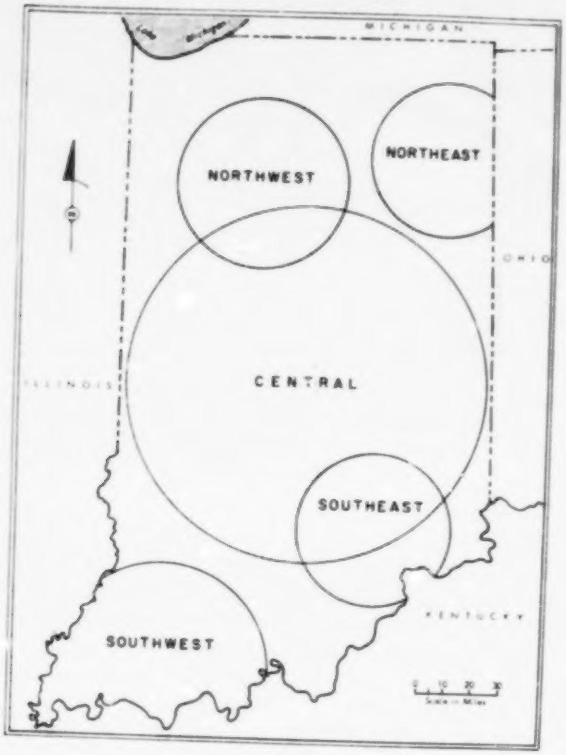

Figure 3. Indiana pasteurized milk sampling areas

**Table 4. Monthly average radionuclide concentrations in Indiana milk, 1965**

| Month 1965 | Concentration, pCi/liter | | | |
|---|---|---|---|---|
| | Strontium-89 | Strontium-90 | Iodine-131 | Cesium-137 |
| January | 0 | 16 | 0 | 65 |
| February | 0 | 15 | 0 | 65 |
| March | 0 | 16 | 0 | 70 |
| April | 0 | 15 | 0 | 70 |
| May | 0 | 14 | 20 | 45 |
| June | 15 | 11 | 20 | 45 |
| July | 0 | 12 | 0 | 30 |
| August | 0 | 15 | 0 | 30 |
| September | 0 | 13 | 0 | 25 |
| October | 0 | 12 | 0 | 30 |
| November | 0 | 13 | 0 | 25 |
| December | 0 | 13 | 0 | 25 |

**Table 3. Radionuclides in Indiana milk, October–December 1965**

| Sampling location | Calcium, g/liter | | | Potassium-40, pCi/liter | | | Strontium-90, pCi/liter | | | Cesium-137, pCi/liter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Oct | Nov | Dec | Oct | Nov | Dec | Oct | Nov | Dec |
| Northeast | 1.22 | 1.13 | 1.14 | 1,330 | 1,310 | 1,380 | 11 | 13 | 11 | 30 | 25 | 30 |
| Southeast | 1.17 | 1.17 | 1.16 | 1,440 | 1,400 | 1,370 | 13 | 14 | 16 | 30 | 25 | 30 |
| Central | 1.20 | 1.15 | 1.12 | 1,350 | 1,400 | 1,400 | 9 | 12 | 12 | 20 | 25 | 25 |
| Southwest | 1.20 | 1.13 | 1.19 | 1,370 | 1,320 | 1,400 | 14 | 14 | 15 | 35 | 20 | 20 |
| Northwest | 1.17 | 1.15 | 1.12 | 1,350 | 1,370 | 1,380 | 14 | 13 | 13 | 30 | 30 | 30 |
| Average | 1.19 | 1.15 | 1.15 | 1,370 | 1,360 | 1,390 | 12 | 13 | 13 | 30 | 25 | 25 |

74

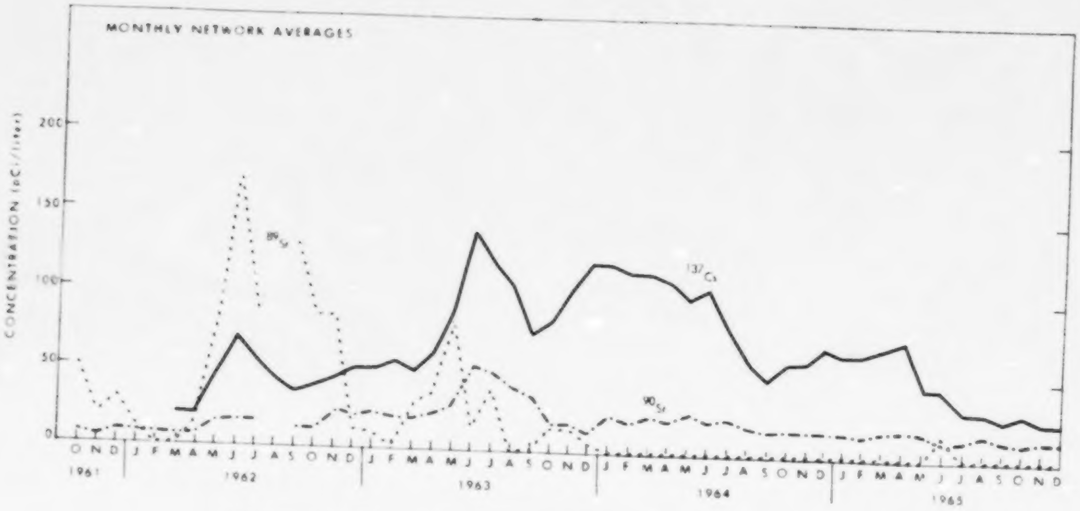

Figure 4. Radionuclide concentrations in Indiana pasteurized milk, 1961-December 1965

Recent coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| Annual Summary 1961-1964 | May 1965 |
| January-March 1965 | August 1965 |
| April-June 1965 | November 1965 |
| July-September 1965 | February 1966 |

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## 3. Michigan Milk Network October-December and Annual Summary 1965

*Division of Occupational Health*
*Michigan Department of Health*

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1964. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (see figure 5). Milkshed samples are composites of dairies in proportion to sales volumes.

Strontium-90 concentrations are determined by an ion exchange method (4). Potassium-40, iodine-131, cesium-137, and barium-lanthanum-140 concentrations are determined by gamma scintillation spectrometry (4).

Table 5 presents the monthly average radionuclide concentrations in Michigan pasteurized milk. Strontium-90 and cesium-137 concentrations are presented graphically in figure 6 to show general trends. A summary of 1965 monthly average concentrations is presented in table 6.

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| November 1962-December 1964 | September 1965 |
| January-June 1965 | November 1965 |
| July-September 1965 | February 1966 |

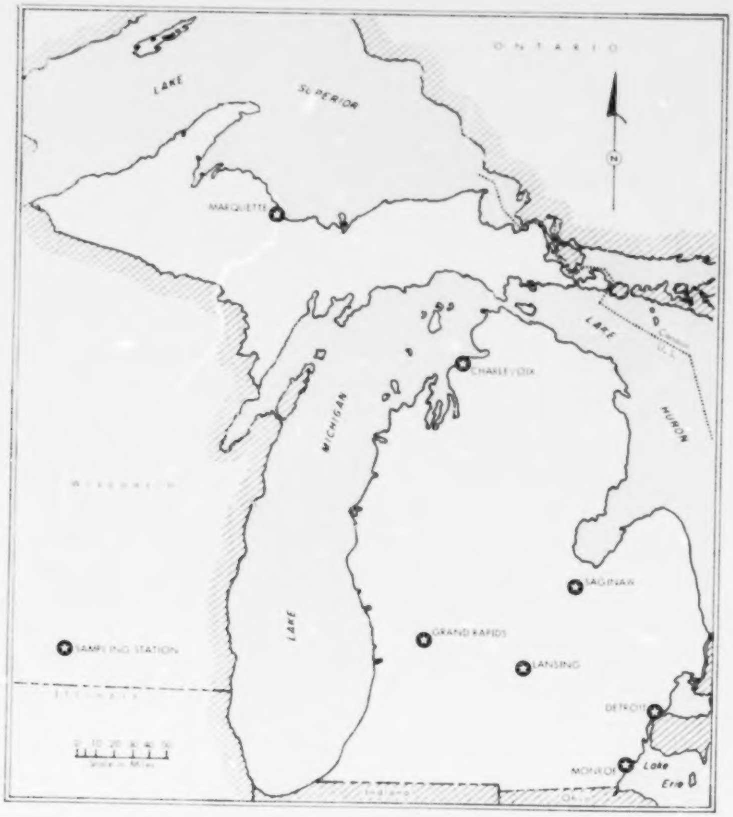
ONTARIO
LAKE SUPERIOR
N
MARQUETTE
CHARLEVOIX
LAKE HURON
LAKE MICHIGAN
WISCONSIN
SAGINAW
GRAND RAPIDS
LANSING
SAMPLING STATION
ILLINOIS
DETROIT
MONROE
Lake Erie
Indiana
Ohio
0 10 20 30 40 50
Scale in Miles

Figure 5. Michigan pasteurized milk network sampling locations

Table 5. Radionuclides in Michigan pasteurized milk, October–December 1965

| Station | Month | Concentration, pCi/liter | | | | |
|---|---|---|---|---|---|---|
| | | Potassium-40 | Strontium-90 | Iodine-131 | Cesium-137 | Barium-lanthanum-140 |
| Charlevoix | October | 1,360 | 19 | <14 | 37 | <4 |
| | November | 1,340 | 17 | <14 | 33 | <4 |
| | December | 1,320 | 24 | <14 | 38 | <4 |
| Detroit | October | 1,310 | 12 | <14 | 21 | <4 |
| | November | 1,310 | 13 | <14 | 21 | <4 |
| | December | 1,350 | 13 | <14 | 21 | <4 |
| Grand Rapids | October | 1,320 | 17 | <14 | 30 | <4 |
| | November | 1,330 | 18 | <14 | 33 | <4 |
| | December | 1,360 | 15 | <14 | 34 | <4 |
| Lansing | October | 1,300 | 15 | <14 | 26 | <4 |
| | November | 1,310 | 14 | <14 | 24 | <4 |
| | December | 1,340 | 13 | <14 | 26 | <4 |
| Marquette | October | 1,300 | 29 | <14 | 57 | <4 |
| | November | 1,330 | 27 | <14 | 53 | <4 |
| | December | 1,390 | 29 | <14 | 55 | <4 |
| Monroe | October | 1,320 | 11 | <14 | 17 | <4 |
| | November | 1,330 | 10 | <14 | 18 | <4 |
| | December | 1,320 | 12 | <14 | 20 | <4 |
| Saginaw | October | 1,360 | 12 | <14 | 23 | <4 |
| | November | 1,320 | 12 | <14 | 23 | <4 |
| | December | 1,390 | 10 | <14 | 22 | <4 |
| Average | October | 1,320 | 16 | <14 | 30 | <4 |
| | November | 1,320 | 16 | <14 | 29 | <4 |
| | December | 1,350 | 17 | <14 | 31 | <4 |

76

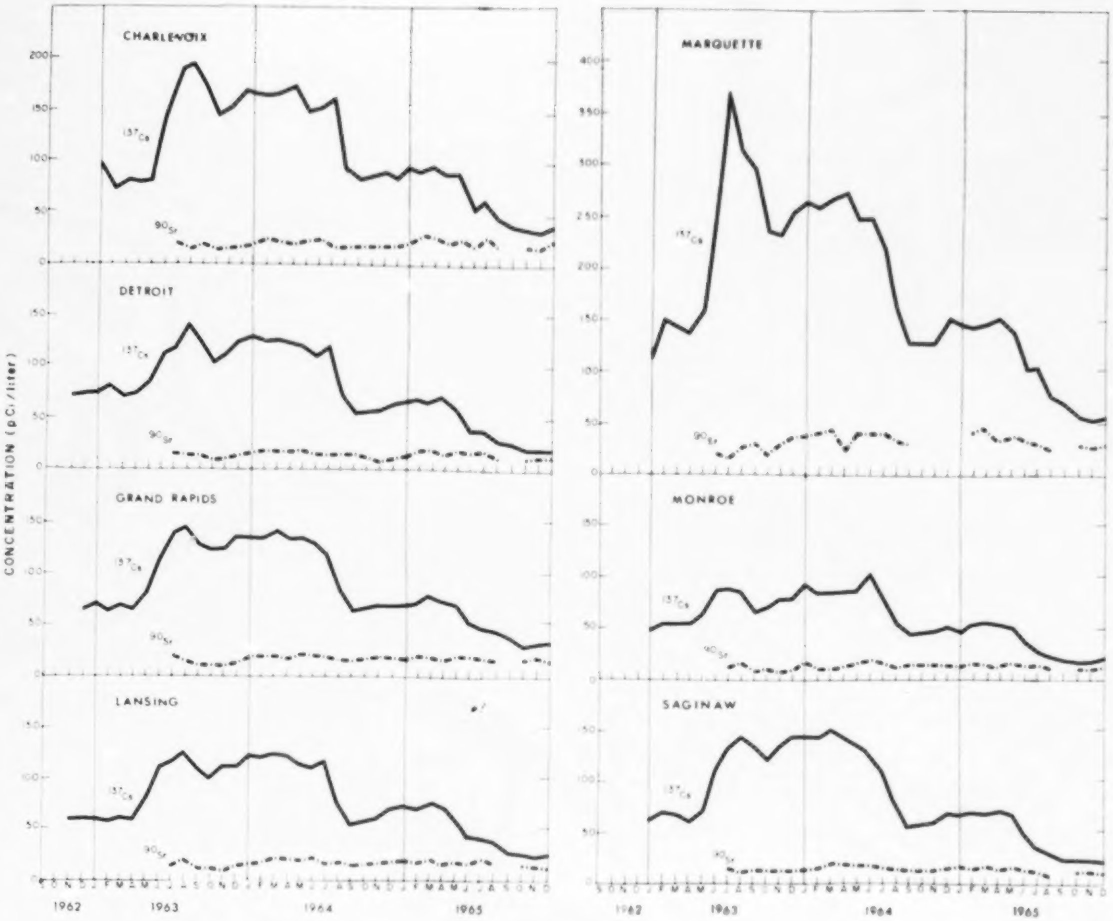

Figure 6. Radionuclide concentrations in Michigan pasteurized milk, 1962–1965

Table 6. Monthly average radionuclide concentrations in Michigan milk, 1965

| Month 1965 | Concentration, pCi/liter | | | | |
|---|---|---|---|---|---|
| | Potassium-40 | Strontium-90 | Iodine-131 | Cesium-137 | Barium-lanthanum-40 |
| Janauary | 1,360 | 18 | <14 | 80 | <4 |
| February | 1,360 | 23 | <14 | 81 | <4 |
| March | 1,335 | 24 | <14 | 83 | <4 |
| April | 1,330 | 20 | <14 | 82 | <4 |
| May | 1,360 | 22 | <14 | 76 | <4 |
| June | 1,320 | 20 | 18 | 55 | <4 |
| July | 1,340 | 18 | <14 | 48 | <4 |
| August | 1,330 | 14 | <14 | 39 | <4 |
| September | 1,320 | NA | <14 | 33 | <4 |
| October | 1,320 | 16 | <14 | 30 | <4 |
| November | 1,320 | 16 | <14 | 29 | <4 |
| December | 1,350 | 17 | <14 | 34 | <4 |

NA, no analysis performed

## 4. Minnesota Milk Network July-December and Annual Summary 1965

*Division of Environmental Health*
*Minnesota Department of Health*

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium-90 concentrations. Presently, monthly samples are collected from eight sampling locations in milksheds, geographically the same as the Minnesota health districts (figure 7), for strontium-90, iodine-131, and cesium-137 analyses. One-liter samples of processed grade A fluid milk are collected at bottling machines in pasteurization plants. The samples are customarily collected in the cities where the Minnesota Health District offices are located. However, it is sometimes convenient to collect at other locations. Such samples are considered representative of the district concerned.

Strontium-90 concentrations are determined radiochemically, while iodine-131 and cesium-137 concentrations are determined by gamma scintillation spectrometry. The analytical procedures are presented in the semiannual report of the Minnesota Department of Health and Rural Cooperative Power Association (5).

Strontium-90 (table 6), iodine-131 (table 7), and cesium-137 (table 8) concentrations in milk are given for July through December 1965. The strontium-90, cesium-137, and

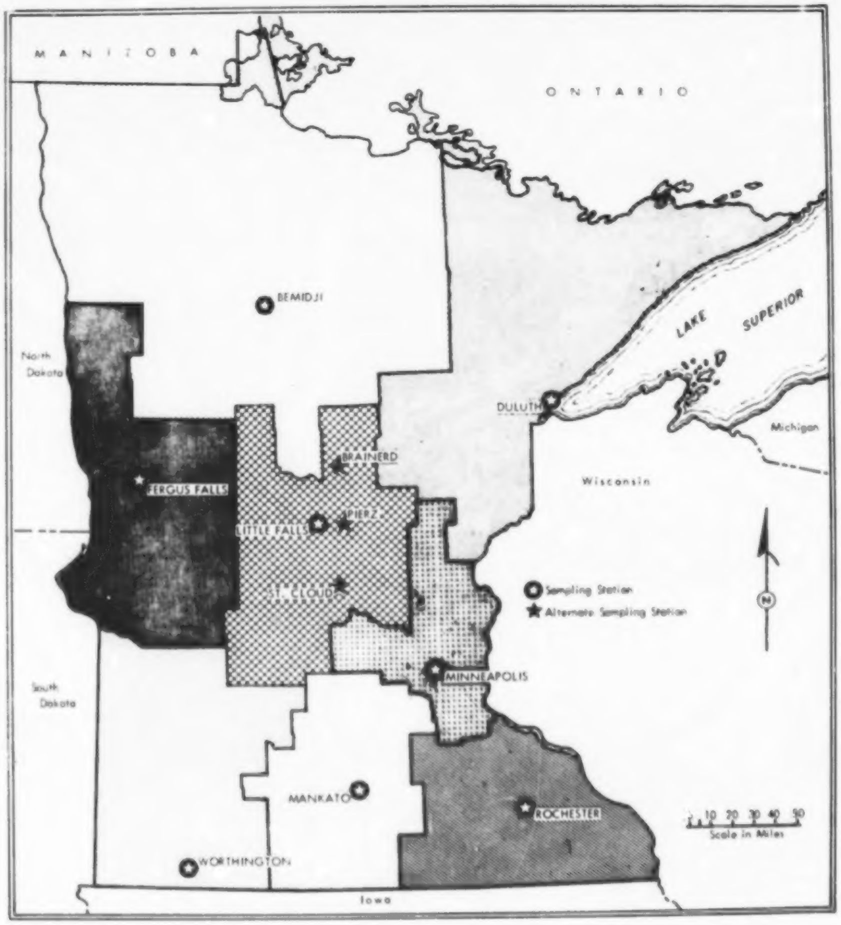
MANITOBA
ONTARIO
BEMIDJI
North Dakota
LAKE SUPERIOR
DULUTH
Michigan
Wisconsin
BRAINERD
FERGUS FALLS
PIERZ
LITTLE FALLS
ST. CLOUD
Sampling Station
Alternate Sampling Station
N
MINNEAPOLIS
South Dakota
MANKATO
ROCHESTER
WORTHINGTON
Iowa
0 10 20 30 40 50
Scale in Miles

Figure 7. Minnesota milk sampling locations

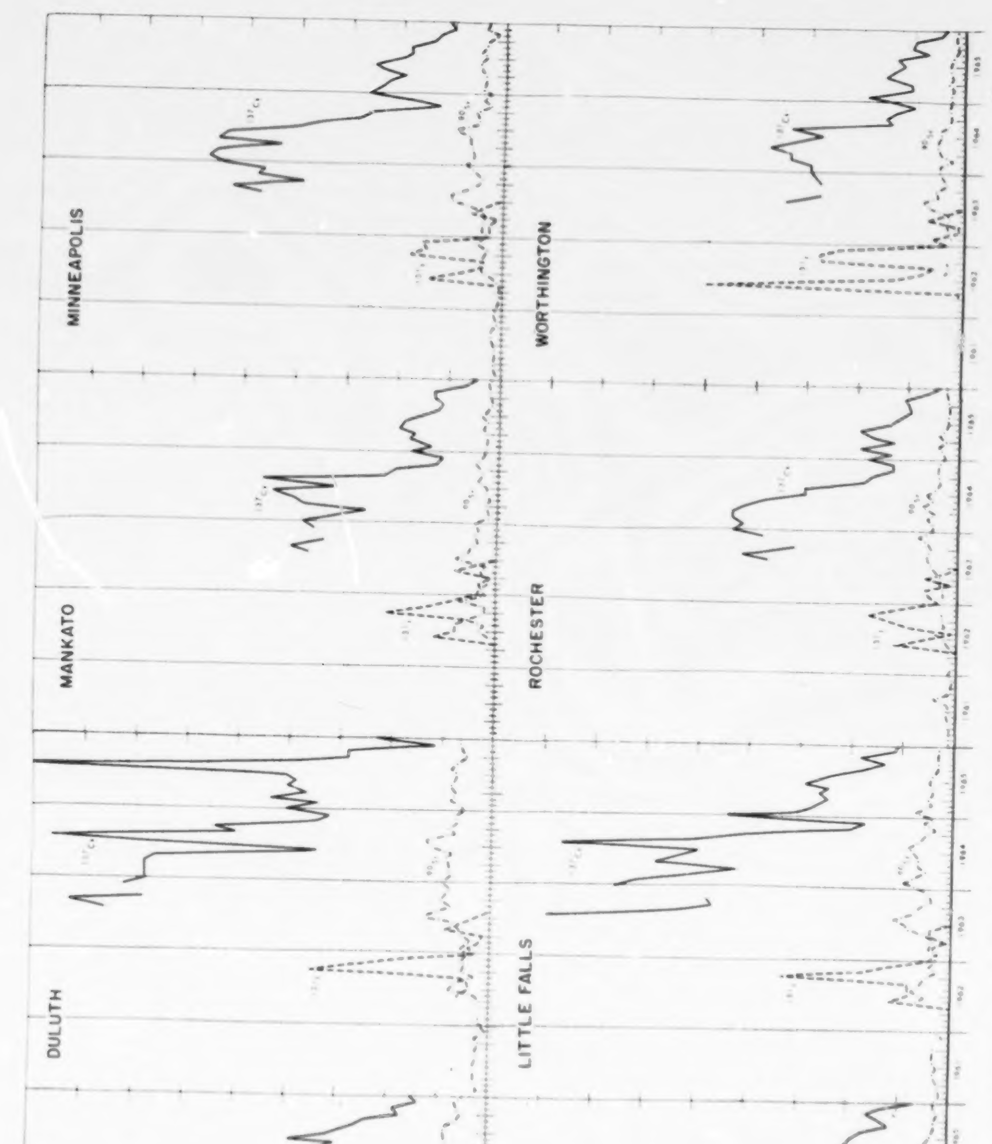

Figure 8. Radionuclide concentrations in Minnesota milk, 1961–1965

**Table 6. Strontium-90 concentrations in Minnesota milk, July–December 1965**

| Sampling location | Strontium-90, pCi/liter | | | | | | |
|---|---|---|---|---|---|---|---|
| | July | Aug | Sept | Oct | Nov | Dec | Average July–Dec 1965 |
| Bemidji | 41 | 29 | 26 | 29 | 31 | 24 | 30 |
| Mankato | 12 | 7 | 9 | 8 | 11 | 8 | 9 |
| Rochester | 12 | 10 | 11 | 12 | 13 | 13 | 12 |
| Duluth | 40 | 33 | 25 | 28 | 31 | 32 | 31 |
| Worthington | 14 | 9 | 7 | 10 | 10 | 8 | 10 |
| Minneapolis | 23 | 19 | 17 | 7 | 18 | 17 | 17 |
| Fergus Falls | 15 | 13 | 13 | 10 | 17 | 14 | 14 |
| Little Falls | 21 | 15 | 15 | 16 | 14 | 16 | 16 |
| Average | 22 | 17 | 15 | 15 | 18 | 16 | 17 |

**Table 7. Iodine-131 concentrations in Minnesota milk, July–December 1965**

| Collection point | Collection date ᵃ | Iodine-131 (pCi/liter) |
|---|---|---|
| Worthington | 7/1/65 | 15 |
| Little Falls | 7/5/65 | 10 |
| Worthington | 8/2/65 | 15 |
| Rochester | 8/2/65 | 10 |
| Rochester | 10/1/65 | 12 |

ᵃ The remaining samples analyzed July through December 1965, showed less than 10 pCi/liter of iodine-131.

iodine-131 concentrations in Minnesota pasteurized milk are presented graphically by milkshed in figure 8 for the period 1962–December 1965. A summary of 1965 monthly average concentrations is presented in table 9.

**Table 8. Cesium-137 concentrations in Minnesota milk, July–December 1965**

| Sampling location | Cesium-137, pCi/liter | | | | | | |
|---|---|---|---|---|---|---|---|
| | July | Aug | Sept | Oct | Nov | Dec | Average July–Dec 1965 |
| Bemidji | 130 | 120 | 86 | 92 | 70 | 92 | 98 |
| Mankato | 59 | 56 | 63 | 64 | 34 | 23 | 50 |
| Rochester | 57 | 48 | 50 | 53 | 32 | 20 | 43 |
| Duluth | 450 | 190 | 140 | 140 | 57 | 110 | 180 |
| Worthington | 66 | 37 | 52 | 49 | 24 | 20 | 41 |
| Minneapolis | 91 | 92 | 70 | 73 | 50 | 55 | 72 |
| Fergus Falls | 85 | 60 | 67 | 81 | 66 | 36 | 66 |
| Little Falls | 120 | 87 | 68 | 91 | 57 | 54 | 80 |
| Average | 134 | 86 | 74 | 80 | 49 | 51 | 79 |

**Table 9. Monthly average radionuclide concentrations in Minnesota milk, 1965**

| Month 1965 | Concentration, pCi/liter | |
|---|---|---|
| | Strontium-90 | Cesium-137 |
| January | 26 | 115 |
| February | 22 | 125 |
| March | 23 | 110 |
| April | 23 | 120 |
| May | 22 | 125 |
| June | 22 | 110 |
| July | 22 | 134 |
| August | 17 | 86 |
| September | 15 | 74 |
| October | 15 | 80 |
| November | 18 | 49 |
| December | 16 | 51 |

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| November 1962–December 1964 | September 1965 |
| January–June 1965 | January 1966 |

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## 5. New York Milk Network July-December and Annual Summary 1965

*Division of Environmental Health Services*
*Department of Health, State of New York*

Pasteurized milk samples collected routinely from six cities (figure 9) are analyzed for strontium-89, strontium-90, iodine-131, and barium-lanthanum-140 by the New York State Department of Health. At Buffalo, Newburgh, and Syracuse milk samples are collected from processing plants on a daily basis and composited weekly for radiochemical analyses. At Massena, samples are composited biweekly, while in New York, a milk sample representing the total milk supply for one day is obtained and composited weekly for analysis. The Albany sample, taken at a marketing point, is analyzed daily for iodine-131 and other gamma-emitting radionuclides before being composited into a weekly sample. In the event that any sample contains iodine-131 concentrations exceeding 100 pCi/liter, increased surveillance is undertaken.

Gamma-emitting radionuclides in milk are

80

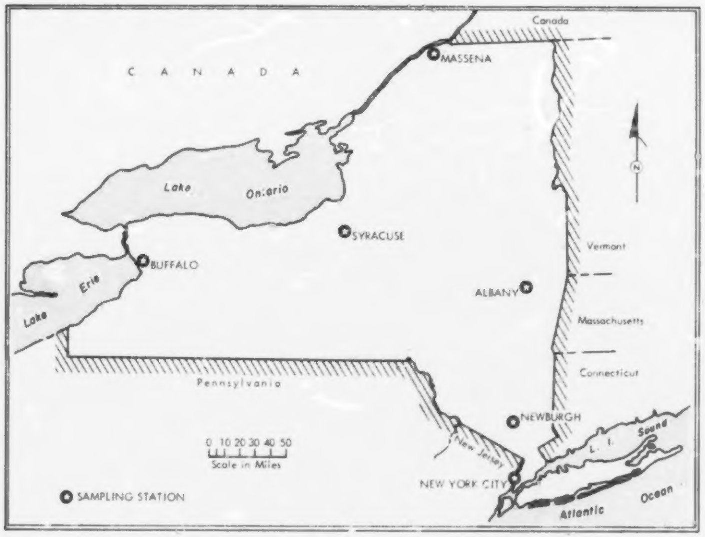
Canada
C A N A D A
MASSENA
Lake Ontario
SYRACUSE
BUFFALO
Lake Erie
ALBANY
Vermont
Massachusetts
Connecticut
Pennsylvania
NEWBURGH
New Jersey
L. I. Sound
0 10 20 30 40 50
Scale in Miles
NEW YORK CITY
SAMPLING STATION
Atlantic Ocean
N

Figure 9. New York milk sampling stations

determined by scintillation spectrometry and the application of a matrix method of analysis (1) to the resultant spectral data.

The analytical procedure for determining strontium-89 and strontium-90 concentrations employs an ion exchange system similar to that developed by Porter and Kahn (2).

The monthly average radionuclide concentrations of strontium-89 (table 10), strontium-90 (table 11), iodine-131 (table 12), and cesium-137 (table 13) are shown for July through December 1965. Cesium-137 and iodine-131 concentrations since September 1961 are presented graphically in figure 10. A summary of 1965 monthly average concentrations is presented in table 14.

**Table 10. Strontium-89 concentrations in New York milk, July–December 1965**

| Sampling location | Strontium-89, pCi/liter | | | | | |
|---|---|---|---|---|---|---|
| | July | Aug | Sept | Oct | Nov | Dec |
| Albany | 4 | <3 | <3 | <3 | <3 | <3 |
| Ashford | NS | 5 | NS | NS | <3 | <3 |
| Bedford | 9 | <3 | <3 | <4 | <3 | NA |
| Buffalo | 4 | 4 | <3 | <3 | <3 | <3 |
| Clarktown | NS | <3 | NS | <3 | NS | NA |
| East Otto | NS | <3 | NS | NS | <3 | <3 |
| Massena | 5 | 7 | <3 | <3 | <3 | <3 |
| Middleburg | 7 | 4 | <3 | <3 | <3 | <3 |
| Mount Pleasant | <3 | <3 | <3 | NA | <3 | <3 |
| Newburgh | 4 | <3 | <3 | <3 | <3 | <3 |
| New York city | 8 | 3 | <3 | <3 | <3 | <3 |
| Oyster Bay | <3 | 8 | 4 | <3 | <3 | NA |
| Syracuse | <3 | <3 | <3 | <3 | <3 | <3 |
| Yaphank | NS | NS | NS | NS | NS | NS |
| Yorkshire | NS | <3 | NS | NS | NS | <3 |
| Yorktown | <3 | <3 | <3 | <3 | <3 | <3 |
| Average | <5 | <4 | <3 | <3 | <3 | <3 |

NA, no analysis
NS, no sample collected

**Table 11. Strontium-90 concentrations in New York milk, July–December 1965**

| Sampling location | Strontium-90, pCi/liter | | | | | |
|---|---|---|---|---|---|---|
| | July | Aug | Sept | Oct | Nov | Dec |
| Albany | 12 | 10 | 13 | 12 | 7 | 7 |
| Ashford | NS | 22 | NS | NS | 16 | 10 |
| Bedford | 22 | 21 | 19 | 27 | 14 | NA |
| Buffalo | 11 | 9 | 10 | 9 | 6 | 7 |
| Clarktown | NS | 6 | NS | 11 | NS | NA |
| East Otto | NS | 20 | NS | NS | 11 | 8 |
| Massena | 11 | 13 | 13 | 10 | 19 | 16 |
| Middleburg | 17 | 15 | 11 | 12 | 10 | 11 |
| Mount Pleasant | 12 | 10 | 7 | NA | 10 | 7 |
| Newburgh | 14 | 14 | 15 | 12 | 12 | 11 |
| New York city | 21 | 18 | 19 | 16 | 13 | 12 |
| Oyster Bay | 17 | 6 | 6 | 11 | 10 | NA |
| Syracuse | 17 | 8 | 7 | 10 | 7 | 7 |
| Yaphank | NS | NS | NS | NS | NS | NS |
| Yorkshire | NS | 22 | NS | NS | NS | 15 |
| Yorktown | 26 | 16 | 18 | 18 | 9 | 19 |
| Average | 16 | 14 | 13 | 13 | 11 | 12 |

NA, no analysis
NS, no sample collected

Table 12. Iodine-131 concentrations in New York milk, July–December 1965

| Sampling location | Iodine-131, pCi/liter | | | | | |
|---|---|---|---|---|---|---|
| | July | Aug | Sept | Oct | Nov | Dec |
| Albany | <20 | <20 | <20 | <20 | <20 | <20 |
| Ashford | NS | <20 | NS | NS | NA | NA |
| Bedford | <20 | <20 | <20 | <20 | <20 | <20 |
| Buffalo | 23 | <20 | <20 | <20 | <20 | <20 |
| Clarktown | NS | <20 | NS | <20 | NS | <20 |
| East Otto | NS | <20 | NS | NS | NA | NA |
| Massena | <20 | <20 | <20 | <20 | <20 | <20 |
| Middleburg | <20 | <20 | <20 | <20 | <20 | <20 |
| Mount Pleasant | <20 | <20 | <20 | <20 | <20 | <20 |
| Newburgh | <20 | <20 | <20 | <20 | <20 | <20 |
| New York | <20 | <20 | <20 | <20 | <20 | <20 |
| Oyster Bay | <20 | <20 | <20 | <20 | <20 | <20 |
| Syracuse | <20 | <20 | <20 | <20 | <20 | <20 |
| Yaphank | NS | NS | NS | NS | NS | NS |
| Yorkshire | NS | <20 | NS | NS | NS | NA |
| Yorktown | <20 | <20 | <20 | <20 | <20 | <20 |
| Average | <21 | <20 | <20 | <20 | <20 | < 20 |

NA, no analysis
NS, no sample collected

Table 13. Cesium-137 concentrations in New York milk, July–December 1965

| Sampling location | Cesium-137, pCi/liter | | | | | |
|---|---|---|---|---|---|---|
| | July | Aug | Sept | Oct | Nov | Dec |
| Albany | 32 | 28 | 23 | 22 | 26 | 27 |
| Ashford | NS | 31 | NS | NS | NA | NA |
| Bedford | 51 | 50 | 29 | 26 | 39 | 27 |
| Buffalo | 31 | 19 | 18 | 23 | 25 | 30 |
| Clarktown | NS | 24 | NS | 20 | NS | 31 |
| East Otto | NS | 39 | NS | NS | NA | NA |
| Massena | 71 | 69 | 47 | 44 | 46 | 52 |
| Middleburg | 33 | 25 | 19 | 23 | 26 | 27 |
| Mount Pleasant | 35 | 35 | 29 | 26 | 27 | 27 |
| Newburgh | 45 | 41 | 36 | 30 | 24 | 28 |
| New York | 48 | 44 | 31 | 32 | 31 | 35 |
| Oyster Bay | 75 | 67 | 56 | 53 | 52 | 48 |
| Syracuse | 29 | 21 | 24 | 20 | 23 | 21 |
| Yaphank | NS | NS | NS | NS | NS | NS |
| Yorkshire | NS | 31 | NS | NS | NS | NS |
| Yorktown | 52 | 50 | 28 | 54 | 31 | 41 |
| Average | 46 | 39 | 31 | 31 | 32 | 33 |

NA, no analysis
NS, no sample collected

Table 14. Monthly average radionuclide concentrations in New York milk, 1965

| Month 1965 | Concentration, pCi/liter | | | |
|---|---|---|---|---|
| | Strontium-89 | Strontium-90 | Iodine-131 | Cesium-137 |
| January | <3 | 14 | <20 | 74 |
| February | <3 | 16 | <20 | 72 |
| March | <3 | 17 | <20 | 71 |
| April | <3 | 16 | <20 | 72 |
| May | <3 | 16 | <20 | 71 |
| June | <3 | 16 | <20 | 62 |
| July | <5 | 16 | <21 | 46 |
| August | <4 | 14 | <20 | 29 |
| September | <3 | 13 | <20 | 31 |
| October | <3 | 13 | <20 | 31 |
| November | <3 | 11 | <20 | 32 |
| December | <3 | 12 | <20 | 33 |

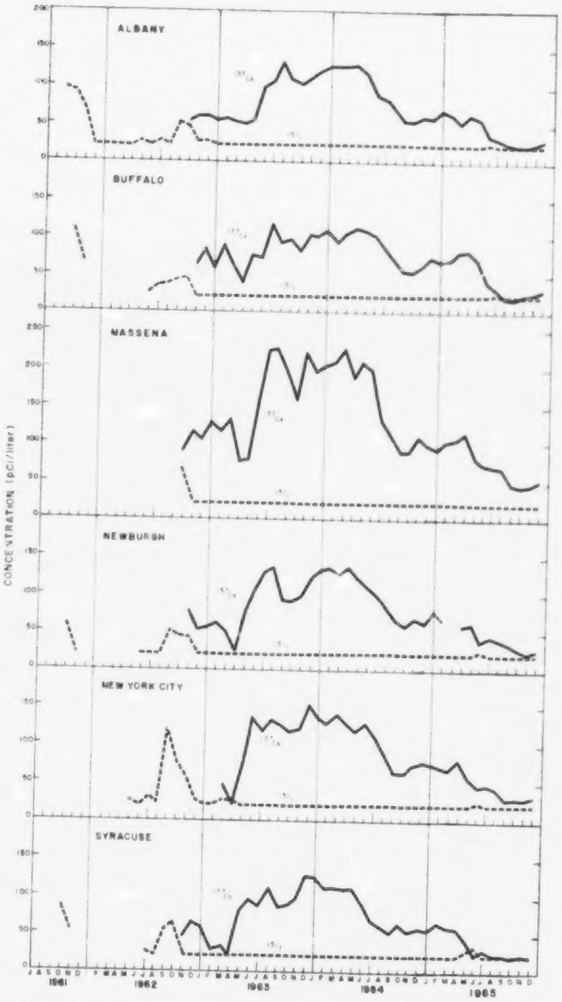

Figure 10. Radionuclide concentrations in New York milk 1961–1965

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| July–September 1964 | April 1965 |
| October–December 1964 | May 1965 |
| January–March 1965 | June 1965 |
| April–June 1965 | January 1966 |

## 6. Pennsylvania Milk Network
## October–December 1965

*Bureau of Environmental Health*
*Pennsylvania Department of Health*

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 11). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Strontium-90 analyses have been carried out since April 1963.

The chemical separation technique for strontium-90 is essentially an ion exchange method described by Porter and Kahn (2).

The monthly average potassium-40, strontium-90, iodine-131, and cesium-137 concentrations in pasteurized milk are given in table 15. For comparative purposes, strontium-90, iodine-131, and cesium-137 concentrations are presented graphically in figure 12. A summary of 1965 annual average concentrations is presented in table 16.

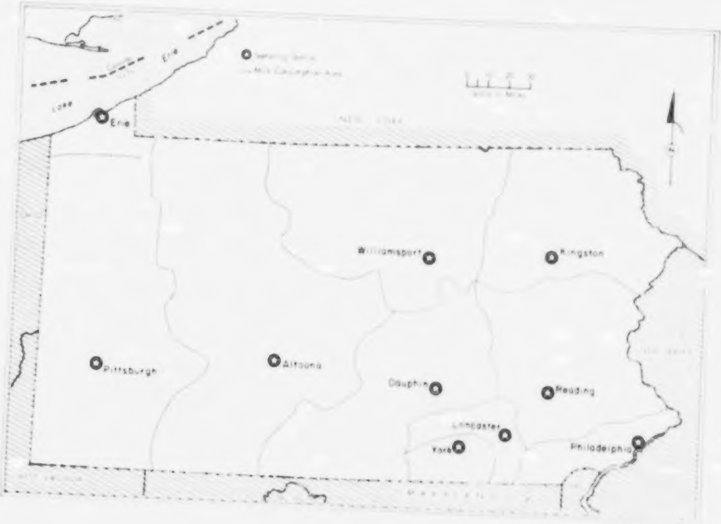

**Figure 11. Pennsylvania pasteurized milk network sampling locations**

**Table 15. Potassium-40, strontium-90, and cesium-137 concentrations in Pennsylvania milk October–December 1965** [a]

| Sampling location | Concentrations, pCi/liter | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Potassium-40 | | | Strontium-90 | | | Cesium-137 | | |
| | Oct | Nov | Dec | Oct | Nov | Dec | Oct | Nov | Dec |
| Altoona | 1,040 | 1,090 | 1,070 | 16 | 15 | 18 | 58 | 64 | 64 |
| Dauphin | 1,060 | 1,050 | 1,210 | 12 | 10 | 17 | 62 | 51 | 65 |
| Erie | 1,050 | 1,070 | 950 | 16 | 12 | 25 | 80 | 74 | 74 |
| Kingston | 1,040 | 1,050 | 1,010 | 19 | 24 | 19 | 64 | 65 | 68 |
| Lancaster | 1,120 | 1,000 | 1,090 | 11 | 14 | 14 | 65 | 53 | 61 |
| Philadelphia | 950 | 980 | 1,000 | 13 | 18 | 17 | 52 | 55 | 50 |
| Pittsburgh | 990 | 970 | 940 | 15 | 25 | 15 | 60 | 61 | 67 |
| Reading | 960 | 980 | 1,060 | 12 | 8 | 10 | 74 | 43 | 58 |
| Williamsport | 1,090 | 1,050 | 900 | 20 | 12 | 21 | 65 | 68 | 56 |
| York | 1,000 | 1,100 | 1,050 | 11 | 12 | 13 | 65 | 66 | 66 |
| Average | 1,030 | 1,035 | 1,030 | 14.8 | 15.0 | 16.9 | 64 | 60 | 62 |

[a] Iodine-131 concentrations for this period were less than the minimum detectable level of 10 pCi/liter.

83

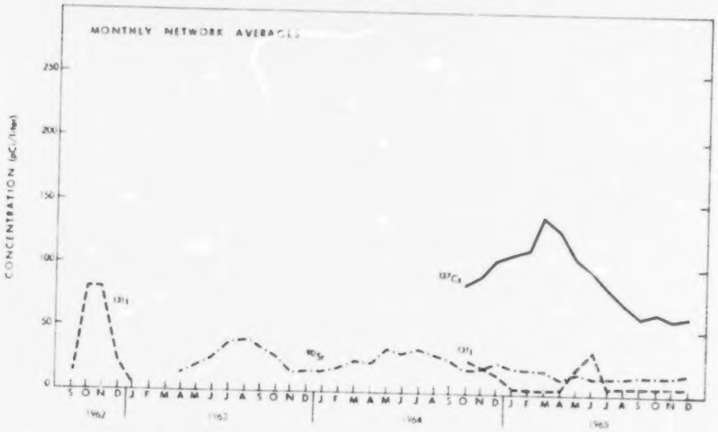

Figure 12. Radionuclide concentrations in Pennsylvania pasteurized milk, 1962-December 1965

**Table 16. Monthly average radionuclide concentrations in Pennsylvania milk, 1965**

| Month 1965 | Concentration, pCi/liter | | | |
|---|---|---|---|---|
| | Potassium-40 | Strontium-90 | Iodine-131 | Cesium-137 |
| January | 1,070 | 23 | <10 | 112 |
| February | 1,080 | 20 | <10 | 116 |
| March | 1,150 | 20 | <10 | 139 |
| April | [a]1,120 | 17 | <10 | 129 |
| May | 1,070 | 19 | 22 | 107 |
| June | 1,050 | 15 | 31 | 95 |
| July | 1,020 | 13 | <10 | 82 |
| August | 1,030 | 13 | <10 | 71 |
| September | 1,020 | 15 | <10 | 61 |
| October | 1,030 | 15 | <10 | 64 |
| November | 1,035 | 15 | <10 | 60 |
| December | 1,030 | 17 | <10 | 62 |

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| August-September 1964 | February 1965 |
| Annual 1964 | June 1965 |
| January-March 1965 | September 1965 |
| April-June 1965 | November 1965 |
| July-September 1965 | February 1966 |

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# FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5), the State of Connecticut's Standard Diet Study. While not based on probability sampling, these networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* are listed below:

| Program | Period reported | Last presented |
|---|---|---|
| Tri-City Diet | May–July 1965 | March 1966 |
| Teenage Diet | February–November 1964 | July 1965 |
| California Diet | January–April 1965 | March 1966 |
| Connecticut Standard Diet | March 1963–December 1964 | July 1965 |

## 1. Radionuclides in Institutional Diet Samples July–September 1965

*Division of Radiological Health*
*Public Health Service*

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program was designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities distributed as shown in figure 1. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Experience with sampling school children of various ages led to a modification in the choice of institutions sampled as of the July 1965 sampling. Previous results showed that the daily intake of teenage girls and children from 9 to 12 years of age was comparable, while teenage boys consumed 20 percent more food per day

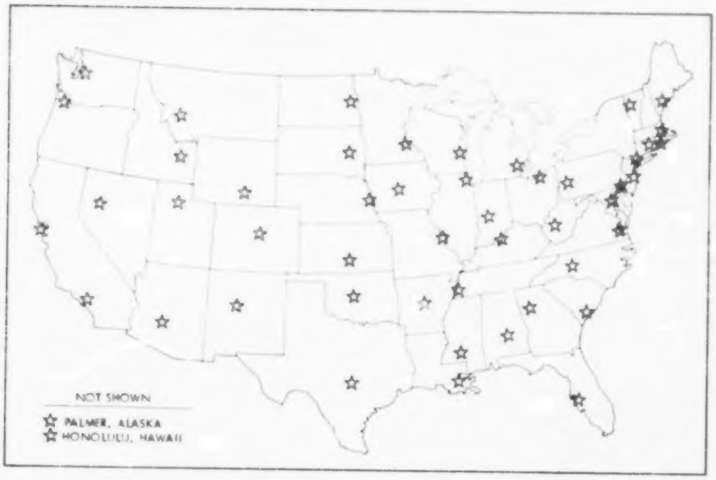

**Figure 1. Institutional diet sampling locations**

(*1, 2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of levels consumed by children.

In general, the sampling procedure is the same at each institution. Each sample supplied by each institution monthly represents the edible portion of the diet for a full 7-day week (21 meals, plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water is not included in the samples but is sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada; the Southeastern Radiological Health Laboratory, Montgomery, Alabama; or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts. A detailed description of sampling and analytical procedures is presented elsewhere (*3*).

*Results*

Table 1 presents the analytical results for institutional diet samples collected from July through September 1965, for children 9 to 12 years of age. Stable elements are reported in g/kg of diet, and radionuclide concentrations are expressed as pCi/kg of diet. The 20 stations reported consist of two stations in each of nine geographic areas of the country, one station in Hawaii and one station in Alaska.

Dietary intakes, presented in table 2, were obtained by multiplying the food consumption rate in kg/day times the concentration values given in table 1. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period where applicable.

Certain of the radionuclide concentration results have been reported as being "less than" (<) a specified value. For purposes of data computations to obtain dietary intakes, "less than" 10 pCi/kg values for iodine-131 and barium-140 were interpreted as zero and "less than" 5 pCi/kg of strontium-89 as 2.5 pCi/kg.

The average dietary intake during this period was 1.83 kg/day and was comparable to the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

While strontium-89 dietary intake remained below detectable levels, the strontium-90 dietary intake during this period remained fairly constant at approximately 23 pCi/day. These results fall within Range II as defined by the Federal Radiation Council (5), indicating that quantitative surveillance and routine control are recommended.

**Table 1. Stable elements and radionuclide concentrations in institutional diets of children, July–September 1955**

| Location of institution | Month (1965) | Stable element concentrations, g/kg of diet | | Radionuclide concentrations, pCi/kg of diet | | | |
|---|---|---|---|---|---|---|---|
| | | Calcium | Potassium | Strontium-89 | Strontium-90 | Cesium-137 | Radium-226 |
| Alaska: Palmer | July | 0.6 | 1.2 | <5 | 17 | 55 | 0.4 |
| | Aug | 0.8 | 1.4 | <5 | 25 | 235 | 0.2 |
| | Sept * | 0.3 | 0.8 | <5 | 5 | 40 | 0.1 |
| Ariz: Phoenix | July | 0.5 | 1.0 | <5 | 6 | 35 | NA |
| | Aug | 0.9 | 0.8 | <5 | 2 | 15 | 0.2 |
| | Sept | 0.7 | 1.5 | <5 | 13 | 50 | 0.4 |
| Ark: Little Rock | July | 0.6 | 1.4 | <5 | 26 | 40 | NA |
| | Aug | 0.5 | 1.2 | <5 | 17 | 25 | NA |
| | Sept | 0.6 | 1.3 | <5 | 24 | 30 | NA |
| Calif: Los Angeles | July | 0.8 | 1.8 | <5 | 9 | 30 | 0.6 |
| | Aug | 0.6 | 1.6 | <5 | 7 | 25 | 0.4 |
| | Sept | 0.7 | 1.5 | <5 | 6 | 40 | 0.4 |
| Colo: Denver | July | 0.7 | 1.2 | <5 | 11 | 55 | 0.5 |
| | Aug | 0.7 | 1.3 | <5 | 9 | 30 | 0.4 |
| | Sept | 0.6 | 1.5 | <5 | 8 | 35 | 0.3 |
| Del: Wilmington | July | 0.8 | 1.6 | 5 | 14 | 50 | 0.6 |
| | Aug | 0.7 | 1.8 | <5 | 10 | 30 | 0.7 |
| | Sept | 0.7 | 1.6 | <5 | 13 | 35 | 0.7 |
| Fla: Tampa | July | 0.8 | 1.7 | <5 | 12 | 130 | NA |
| | Aug | 0.7 | 1.8 | <5 | 10 | 105 | NA |
| | Sept | 0.8 | 1.7 | <5 | 14 | 135 | NA |
| Hawaii: Honolulu | July | 0.5 | 1.0 | <5 | 9 | 35 | 0.6 |
| | Aug | 0.5 | 1.3 | <5 | 9 | 45 | NA |
| | Sept | NS | NS | NS | NS | NS | NS |
| Idaho: Idaho Falls | July | 1.0 | 1.5 | 20 | 34 | 65 | 0.7 |
| | Aug | 1.0 | 1.4 | <5 | 12 | 65 | 0.6 |
| | Sept | 1.0 | 1.6 | <5 | 9 | 40 | 0.5 |
| Ill: Chicago | July | 0.8 | 1.3 | <5 | 9 | 50 | 0.4 |
| | Aug | 0.8 | 1.6 | <5 | 9 | 30 | 0.5 |
| | Sept | 0.7 | 1.6 | <5 | 9 | 40 | 0.4 |
| Ky: Louisville | July | 0.5 | 1.0 | <5 | 12 | 35 | NA |
| | Aug | 0.6 | 1.6 | <5 | 12 | 30 | NA |
| | Sept | 0.6 | 1.3 | <5 | 19 | 30 | NA |
| La: New Orleans | July | 0.8 | 1.6 | <5 | 24 | 45 | NA |
| | Aug | 0.6 | 1.6 | <5 | 17 | 40 | NA |
| | Sept | 0.6 | 1.5 | <5 | 22 | 40 | NA |
| Mass: Boston | July | 0.5 | 1.4 | <5 | 10 | 40 | 0.5 |
| | Aug | 0.6 | 1.4 | <5 | 12 | 50 | 0.6 |
| | Sept | 0.8 | 1.7 | <5 | 10 | 35 | 0.7 |
| Mo: St. Louis | July | 0.7 | 1.5 | <5 | 14 | 30 | 0.8 |
| | Aug | 0.7 | 1.7 | <5 | 13 | 25 | 0.7 |
| | Sept | 0.8 | 1.6 | <5 | 11 | 45 | 0.7 |
| Ohio: Cleveland | July | 0.7 | 1.6 | <5 | 12 | 40 | 0.5 |
| | Aug | 0.6 | 1.8 | <5 | 8 | 40 | 0.7 |
| | Sept | 0.6 | 1.7 | <5 | 9 | 50 | 0.6 |
| Pa: Pittsburgh | July | 0.6 | 1.6 | 5 | 10 | 35 | 0.8 |
| | Aug | 0.5 | 1.4 | 5 | 12 | 40 | 0.6 |
| | Sept | 0.6 | 1.4 | <5 | 8 | 40 | 0.8 |
| S.C: Charleston | July | 0.6 | 1.3 | <5 | 15 | 40 | NA |
| | Aug | 0.7 | 1.1 | <5 | 20 | 55 | NA |
| | Sept | 0.7 | 1.6 | <5 | 18 | 55 | NA |
| S. Dak: Sioux Falls | July | 0.9 | 1.8 | 10 | 17 | 75 | 0.6 |
| | Aug | 0.8 | 1.6 | <5 | 16 | 50 | 0.7 |
| | Sept | 0.6 | 1.6 | <5 | 12 | 60 | 0.5 |
| Tex: Austin | July | 0.5 | 1.0 | <5 | 8 | 20 | NA |
| | Aug | 0.4 | 1.1 | <5 | 8 | 25 | NA |
| | Sept | 0.7 | 2.0 | <5 | 12 | 30 | NA |
| Vt: Burlington | July | 0.9 | 1.4 | 5 | 13 | 65 | 0.7 |
| | Aug | 1.0 | 2.0 | <5 | 20 | 60 | 0.7 |
| | Sept | 0.6 | 1.6 | <5 | 10 | 40 | 0.6 |
| Wash: Seattle | July | 0.7 | 1.7 | <5 | 20 | 80 | 0.4 |
| | Aug | 0.8 | 2.0 | <5 | 23 | 60 | 0.2 |
| | Sept | 0.7 | 2.0 | <5 | 15 | 60 | 0.4 |
| Institutional average | July | 0.7 | 1.4 | <5 | 14 | 50 | 0.4 |
| | Aug | 0.7 | 1.5 | <5 | 13 | 50 | 0.3 |
| | Sept | 0.7 | 1.6 | <5 | 12 | 45 | 0.4 |

[a] Does not contain milk portion of diet (lost in shipment).
NA, no analysis
NS, no sample

57

## Table 2. Intake of stable elements and radionuclides in institutional total diet for children (9–12 years of age) July–September 1965

| Location of institution | Month (1965) | Total weight (kg/day) | Stable elements, g/day |  | Radionuclide intakes, pCi/day |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  | Calcium | Potassium | Strontium-89 | Strontium-90 | Cesium-137 | Radium-226 |
| Alaska: Palmer | July | 1.94 | 1.2 | 2.3 | 5 | 33 | 105 | 0.8 |
|  | Aug | 1.64 | 1.3 | 2.3 | 5 | 41 | 385 | 0.3 |
|  | Sept | [a] 0.94 | 0.3 | 0.8 | 5 | 5 | 40 | 0.1 |
| Ariz: Phoenix | July | 1.64 | 0.8 | 1.6 | 5 | 10 | 55 | NA |
|  | Aug | 1.54 | 1.4 | 1.2 | 5 | 3 | 25 | 0.3 |
|  | Sept | 1.85 | 1.3 | 2.8 | 5 | 24 | 95 | 0.7 |
| Ark: Little Rock | July | 1.98 | 1.2 | 2.8 | 5 | 51 | 80 | NA |
|  | Aug | 1.58 | 0.8 | 1.9 | 5 | 27 | 40 | NA |
|  | Sept | 1.30 | 0.8 | 1.7 | 5 | 31 | 40 | NA |
| Calif: Los Angeles | July | 1.79 | 1.4 | 3.2 | 5 | 16 | 55 | 1.1 |
|  | Aug | 1.70 | 1.0 | 2.7 | 5 | 12 | 40 | 0.7 |
|  | Sept | 1.91 | 1.1 | 2.9 | 5 | 12 | 80 | 0.8 |
| Colo: Denver | July | 2.49 | 1.7 | 3.0 | 5 | 27 | 135 | 1.2 |
|  | Aug | 2.40 | 1.7 | 3.1 | 5 | 22 | 70 | 1.0 |
|  | Sept | 2.39 | 1.4 | 3.6 | 5 | 19 | 85 | 0.7 |
| Del: Wilmington | July | 1.77 | 1.4 | 2.8 | 10 | 25 | 90 | 1.4 |
|  | Aug | 2.03 | 1.4 | 3.7 | 5 | 20 | 60 | 1.4 |
|  | Sept | 2.11 | 1.5 | 3.4 | 5 | 27 | 75 | 1.5 |
| Fla: Tampa | July | 2.05 | 1.6 | 3.5 | 5 | 25 | 265 | NA |
|  | Aug | 2.12 | 1.5 | 3.8 | 5 | 21 | 225 | NA |
|  | Sept | 1.87 | 1.5 | 3.2 | 5 | 26 | 250 | NA |
| Hawaii: Honolulu | July | [b] 1.72 | 0.9 | 1.7 | 5 | 15 | 60 | 1.0 |
|  | Aug | 1.89 | 0.9 | 2.5 | 5 | 17 | 85 | NA |
|  | Sept | NS | NS | NS | NS | NS | NS | NS |
| Idaho: Idaho Falls | July | [c] 2.03 | 2.0 | 3.0 | 40 | 69 | 130 | 1.4 |
|  | Aug | [b] 1.98 | 2.0 | 2.8 | 5 | 24 | 130 | 1.2 |
|  | Sept | [b] 2.32 | 2.3 | 3.7 | 5 | 21 | 95 | 1.2 |
| Ill: Chicago | July | 1.57 | 1.3 | 2.0 | 5 | 14 | 80 | 0.6 |
|  | Aug | 1.57 | 1.3 | 2.5 | 5 | 14 | 45 | 0.8 |
|  | Sept | 1.86 | 1.3 | 3.0 | 5 | 17 | 75 | 0.7 |
| Ky: Louisville | July | 1.74 | 0.9 | 1.7 | 5 | 21 | 60 | NA |
|  | Aug | 1.72 | 1.0 | 2.8 | 5 | 21 | 50 | NA |
|  | Sept | 1.41 | 0.8 | 1.8 | 5 | 27 | 40 | NA |
| La: New Orleans | July | 2.24 | 1.8 | 3.6 | 5 | 54 | 100 | NA |
|  | Aug | 2.49 | 1.5 | 4.0 | 5 | 42 | 100 | NA |
|  | Sept | [c] 1.56 | 0.9 | 2.3 | 5 | 34 | 60 | NA |
| Mass: Boston | July | 1.97 | 1.0 | 2.8 | 5 | 20 | 80 | 1.0 |
|  | Aug | 2.32 | 1.4 | 3.2 | 5 | 28 | 115 | 1.4 |
|  | Sept | 2.28 | 1.8 | 3.9 | 5 | 23 | 80 | 1.6 |
| Mo: St. Louis | July | 2.43 | 1.7 | 3.6 | 5 | 34 | 75 | 1.9 |
|  | Aug | 2.65 | 1.9 | 4.5 | 5 | 34 | 65 | 1.9 |
|  | Sept | 2.38 | 1.9 | 3.8 | 5 | 26 | 105 | 1.7 |
| Ohio: Cleveland | July | 1.42 | 1.0 | 2.3 | 5 | 17 | 55 | 0.7 |
|  | Aug | 1.39 | 0.8 | 2.5 | 5 | 11 | 55 | 1.0 |
|  | Sept | 1.89 | 1.1 | 3.2 | 5 | 17 | 95 | 1.1 |
| Pa: Pittsburgh | July | [c] 2.33 | 1.4 | 3.7 | 10 | 23 | 80 | 1.9 |
|  | Aug | 2.35 | 1.2 | 3.3 | 10 | 28 | 95 | 1.4 |
|  | Sept | [c] 2.41 | 1.4 | 3.4 | 5 | 19 | 95 | 1.9 |
| S.C: Charleston | July | 1.02 | 0.6 | 1.3 | 5 | 15 | 40 | NA |
|  | Aug | 1.83 | 1.3 | 2.0 | 5 | 37 | 100 | NA |
|  | Sept | 1.50 | 1.0 | 2.4 | 5 | 27 | 85 | NA |
| S.Dak: Sioux Falls | July | 1.84 | 1.7 | 3.3 | 20 | 31 | 140 | 1.1 |
|  | Aug | 1.72 | 1.4 | 2.8 | 5 | 28 | 85 | 1.2 |
|  | Sept | 1.67 | 1.0 | 2.7 | 5 | 20 | 100 | 0.8 |
| Tex: Austin | July | 2.00 | 1.0 | 2.0 | 5 | 16 | 40 | NA |
|  | Aug | [b] 1.06 | 0.4 | 1.2 | 5 | 8 | 25 | NA |
|  | Sept | 1.25 | 0.9 | 2.5 | 5 | 15 | 40 | NA |
| Vt: Burlington | July | 1.27 | 1.1 | 1.8 | 5 | 17 | 85 | 0.9 |
|  | Aug | 1.32 | 1.3 | 2.6 | 5 | 26 | 80 | 0.9 |
|  | Sept | 1.45 | 0.9 | 2.3 | 5 | 14 | 60 | 0.9 |
| Wash: Seattle | July | [c] 1.55 | 1.1 | 2.6 | 5 | 31 | 125 | 0.6 |
|  | Aug | [c] 1.49 | 1.2 | 3.0 | 5 | 34 | 90 | 0.3 |
|  | Sept | [b] 1.72 | 1.2 | 3.4 | 5 | 26 | 105 | 0.7 |
| Institutional average | July | 1.83 | 1.3 | 2.6 | 5 | 25 | 90 | 1.0 |
|  | Aug | 1.90 | 1.3 | 2.9 | 5 | 24 | 95 | 1.0 |
|  | Sept | 1.76 | 1.2 | 2.8 | 5 | 21 | 85 | 1.0 |

[a] Does not contain milk portion of diet (lost in shipment).
[b] Data for these months were not used in the average, because food samples were collected from children over 12 years of age.
[c] Data for these months were not used in the average, because food samples were collected from children whose ages were unknown.
NA, no analysis
NS, no sample

Cesium-137 intakes were observed to steadily decrease during this period following the peak observed in 1964 (*4*). During this period, both barium-140 and iodine-131 concentrations were below detectable levels.

Recent coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| January-March 1964 | October 1964 |
| April-June 1964 | January 1965 |
| July-September 1964 | April 1965 |
| October-December 1964 | July 1965 |
| Annual averages 1964 | July 1965 |
| January-March 1965 | October 1965 |
| April-June 1965 | February 1966 |

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# Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below:

| Program | Period reported | Last presented |
|---|---|---|
| Radiostrontium in Tap Water (HASL) | January–June 1965 | December 1965 |
| Colorado River Basin | 1962–1964 | November 1965 |
| Coast Guard Water Sampling | 1964 | November 1965 |
| Drinking Water Analysis | 1962 | October 1965 |
| California Water Sampling | January–June 1965 | March 1966 |
| Florida Water Sampling | 1964 | November 1965 |
| Kentucky Water Sampling | May 1963–June 1964 | March 1965 |
| Minnesota Surface Water Sampling | January–June 1965 | February 1966 |
| New York Surface Water Sampling | January–June 1965 | January 1966 |
| North Carolina Water Sampling | 1964 | November 1965 |
| Lower Columbia River Radiological Survey in Oregon | August 1963–July 1964 | October 1965 |

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962. Public Health Service Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

# GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, NOVEMBER 1965

*Basic Data Program, Federal Water Pollution Control Administration*

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table acording to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the December 1965 issue of *Radiological Health Data.*

Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater, or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance, as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this

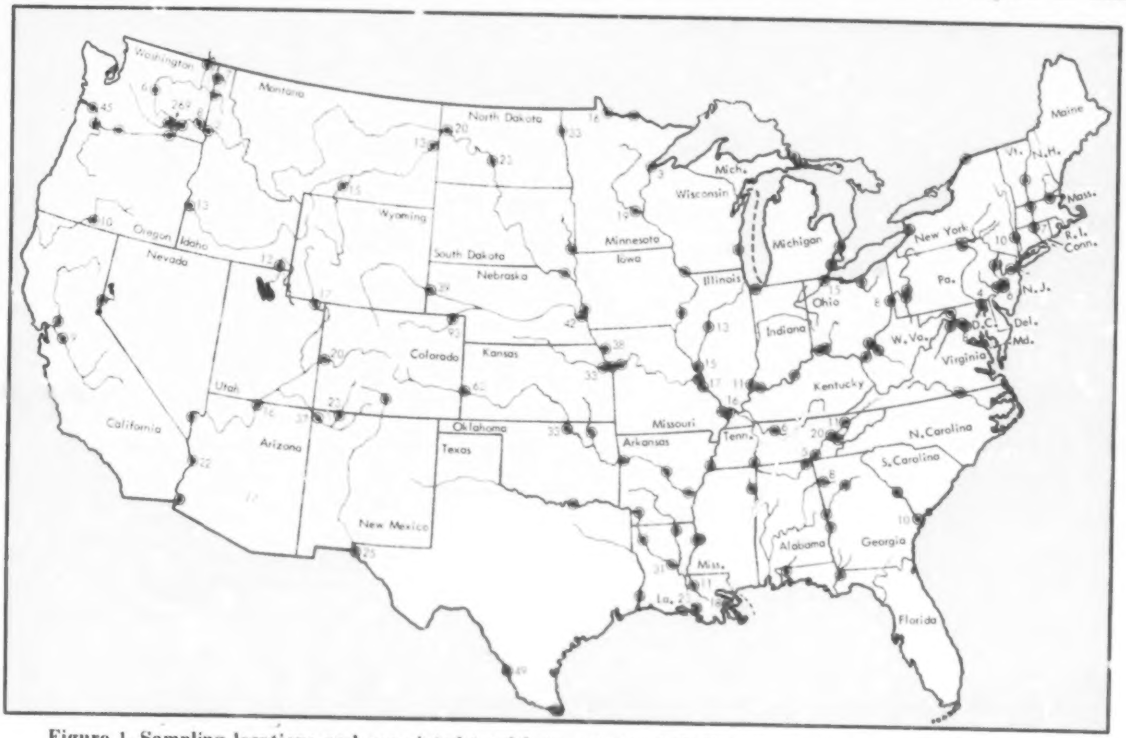
Washington
Montana
North Dakota
Minnesota
Wisconsin
Mich.
Michigan
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
New York
Pa.
N.J.
Del.
Md.
D.C.
Oregon
Idaho
Wyoming
South Dakota
Nebraska
Iowa
Illinois
Indiana
Ohio
W. Va.
Virginia
Nevada
Utah
Colorado
Kansas
Missouri
Kentucky
California
Arizona
New Mexico
Oklahoma
Texas
Arkansas
Tenn.
N. Carolina
S. Carolina
Miss.
Alabama
Georgia
La.
Florida

**Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, November 1965**

time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During October and November 1965, the following stations showed alpha values in excess of 15 pCi/liter or beta values in excess of 150 pCi/liter in either the dissolved or suspended solids:

| | |
|---|---|
| South Platte River: | Julesburg, Colorado |
| North Platte River: | Henry, Nebraska |
| Arkansas River: | Coolidge, Kansas |
| Columbia River: | Pasco, Washington |

The following stations showed a decline in alpha radioactivity on suspended solids to values of 15 pCi/liter or less:

| | |
|---|---|
| Rio Grande: | Laredo, Texas |
| San Juan River: | Shiprock, New Mexico |

## REFERENCES

(1) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(2) Ibid., 1959 Edition.

(3) Ibid., 1960 Edition.

(4) Ibid., 1961 Edition.

(5) Ibid., 1962 Edition.

(6) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (Revised) 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

**Table 1. Radioactivity in raw surface waters, November 1965**

| Station | Average concentrations, pCi/liter | | | | | |
|---|---|---|---|---|---|---|
| | Beta | | | Alpha | | |
| | Suspended | Dissolved | Total | Suspended | Dissolved | Total |
| Animas River: | | | | | | |
| Cedar Hill, N. Mex | 10 | 13 | 23 | 2 | 2 | 4 |
| Arkansas River: | | | | | | |
| Coolidge, Kans | 16 | 47 | 63 | 3 | 37 | 40 |
| Ponca City, Okla | 12 | 21 | 33 | 2 | 8 | 10 |
| Atchafalaya River: | | | | | | |
| Morgan City, La | 7 | 16 | 23 | 2 | 1 | 3 |
| Bear River: | | | | | | |
| Preston, Idaho | 1 | 12 | 13 | 0 | 4 | 4 |
| Big Horn River: | | | | | | |
| Hardin, Mont | 3 | 12 | 15 | 0 | 7 | 7 |
| Chena River: | | | | | | |
| Fairbanks, Alaska | 1 | 2 | 3 | 0 | 0 | 0 |
| Clearwater River: | | | | | | |
| Lewiston, Idaho | <1 | 3 | 3 | 0 | 0 | 0 |
| Clinch River: | | | | | | |
| Clinton, Tenn | 1 | 10 | 11 | 0 | 1 | 1 |
| Kingston, Tenn | 4 | 16 | 20 | <1 | <1 | <1 |
| Colorado River: | | | | | | |
| Loma, Colo | 8 | 12 | 20 | 2 | 6 | 8 |
| Page, Ariz | 1 | 15 | 16 | 0 | 3 | 3 |
| Parker Dam, Calif-Ariz | 1 | 21 | 22 | 0 | 12 | 12 |
| Columbia River: | | | | | | |
| Wenatchee, Wash | 0 | 6 | 6 | 0 | 1 | 1 |
| Pasco, Wash | 52 | 217 | 269 | 0 | <1 | <1 |
| Clatskanie, Ore | 5 | 40 | 45 | 0 | 1 | 1 |
| Connecticut River: | | | | | | |
| Enfield Dam, Conn | 1 | 6 | 7 | 0 | 0 | 0 |
| Coosa River: | | | | | | |
| Rome, Ga | 3 | 5 | 8 | <1 | 0 | <1 |
| Cumberland River: | | | | | | |
| Cheatham Lock, Tenn | 1 | 5 | 6 | 0 | 0 | 0 |
| Delaware River: | | | | | | |
| Philadelphia, Pa | 1 | 5 | 6 | 1 | 0 | 1 |
| Great Lakes: | | | | | | |
| Duluth, Minn | 0 | 3 | 3 | 0 | 0 | 0 |
| Green River: | | | | | | |
| Dutch John, Utah | 1 | 16 | 17 | 0 | 4 | 4 |
| Hudson River: | | | | | | |
| Poughkeepsie, N.Y | 2 | 8 | 10 | 0 | 0 | 0 |
| Illinois River: | | | | | | |
| Peoria, Ill | 3 | 10 | 13 | 1 | 2 | 3 |
| Grafton, Ill | 1 | 14 | 15 | 1 | 2 | 3 |
| Kansas River: | | | | | | |
| DeSoto, Kans | 9 | 24 | 33 | 4 | 4 | 8 |
| Klamath River: | | | | | | |
| Keno, Ore | 3 | 7 | 10 | 0 | 0 | 0 |
| Maumee River: | | | | | | |
| Toledo, Ohio | 4 | 11 | 15 | 1 | 0 | 1 |
| Mississippi River: | | | | | | |
| St. Paul, Minn | 2 | 17 | 19 | 0 | 1 | 1 |
| E. St. Louis, Ill | 4 | 13 | 17 | 1 | 2 | 3 |
| New Roads, La | 5 | 6 | 11 | 1 | 2 | 3 |
| New Orleans, La | 3 | 15 | 18 | 0 | 2 | 2 |
| Missouri River: | | | | | | |
| Williston, N. Dak | 3 | 17 | 20 | 0 | 4 | 4 |
| Bismarck, N. Dak | 5 | 18 | 23 | 1 | 4 | 5 |
| St. Joseph, Mo | 16 | 22 | 38 | 4 | 6 | 10 |
| North Platte River: | | | | | | |
| Henry, Nebr | 3 | 36 | 39 | <1 | 26 | 26 |
| Ohio River: | | | | | | |
| Toronto, Ohio | 1 | 7 | 8 | 0 | 0 | 0 |
| Cairo, Ill | 3 | 13 | 16 | 0 | 0 | 0 |
| Pend Oreille River: | | | | | | |
| Albeni Falls Dam, Idaho | 1 | 6 | 7 | 0 | 1 | 1 |
| Platte River: | | | | | | |
| Plattsmouth, Nebr | 15 | 27 | 42 | 4 | 10 | 14 |
| Potomac River: | | | | | | |
| Washington, D.C | 1 | 7 | 8 | 0 | 0 | 0 |
| Rainy River: | | | | | | |
| Baudette, Minn | 2 | 14 | 16 | <1 | <1 | <1 |
| Red River, North: | | | | | | |
| Grand Forks, N. Dak | 2 | 31 | 33 | 0 | 3 | 3 |
| Red River, South: | | | | | | |
| Alexandria, La | 9 | 22 | 31 | 3 | 2 | 5 |
| Rio Grande: | | | | | | |
| El Paso, Tex | 2 | 23 | 25 | 0 | 5 | 5 |
| Laredo, Tex | 33 | 16 | 49 | 12 | 5 | 17 |
| San Joaquin River: | | | | | | |
| Vernalis, Calif | 1 | 8 | 9 | 0 | 3 | 3 |
| San Juan River: | | | | | | |
| Shiprock, N. Mex | 27 | 10 | 37 | 10 | 2 | 12 |
| Savannah River: | | | | | | |
| Port Wentworth, Ga | 2 | 8 | 10 | 0 | 0 | 0 |
| Snake River: | | | | | | |
| Payette, Idaho | 1 | 12 | 13 | 0 | 5 | 5 |
| Wawawai, Wash | 0 | 8 | 8 | 0 | 3 | 3 |
| South Platte River: | | | | | | |
| Julesburg, Colo | 28 | 65 | 93 | 8 | 38 | 46 |
| Susquehanna River: | | | | | | |
| Conowingo, Md | 0 | 4 | 4 | 0 | 0 | 0 |
| Tennessee River: | | | | | | |
| Chattanooga, Tenn | 0 | 5 | 5 | 0 | 1 | 1 |
| Wabash River: | | | | | | |
| New Harmony, Ind | 4 | 7 | 11 | 0 | 1 | 1 |
| Yellowstone River: | | | | | | |
| Sidney, Mont | 2 | 11 | 13 | 0 | 3 | 3 |
| Maximum | 52 | 217 | 269 | 12 | 38 | 46 |
| Minimum | 0 | 2 | 3 | 0 | 0 | 0 |

# RADIOACTIVITY IN WASHINGTON SURFACE WATER JULY 1964-JUNE 1965[1]

*Washington State Department of Health*

Radioanalysis of surface water samples collected throughout the State of Washington is one of the major functions of the Washington State Department of Health radiation surveillance program. Most surface water samples are collected quarterly from 70 stations located on 59 rivers throughout the State. These samples are collected by the Washington Pollution Control Commission and are sent to the Department of Health for radiological analyses. A few locations are sampled less frequently, and selected stations on the Columbia River are sampled weekly by local health department sanitarians.

All surface water samples are collected as grab samples in 2-liter plastic bottles. Two milliliters of concentrated nitric acid are added to the sample before shipment to the laboratory to prevent loss of activity to the container.

## *Analytical procedures*

Surface water samples are placed in stainless-steel Marinelli beakers for the gamma analyses. Distilled water is added when necessary to obtain 2-liter volumes for standardizing counting geometry. These samples are gamma scanned for 100 minutes approximately 2 weeks after collection. This 2-week period permits the decay of short-lived isotopes (sodium-24, arsenic-76, neptunium-239) in Columbia River water samples. The matrix method, utilizing a 4 by 4 matrix, permits the estimation of chromium-51, ruthenium-106, zirconium-95, and zinc-65. Results are extrapolated to the date of collection.

The gamma-counting equipment consists of a 3 by 3-inch gamma-scintillation crystal and a 512-channel analyzer. A 1-minute count each day of a cesium-137 standard is performed as an efficiency check, and a 10-minute count each week is done to check the resolution. An 800-minute count each week is taken to check the background. Table 1 gives the gamma efficiencies and detectability limits for this system.

After the gamma scan, the water samples receive further preparation and are beta counted approximately 18 days after sample collection for suspended and soluble radioactivity. The separation of dissolved and suspended activity is accomplished by filtering the acidified sample (Whatman #42 filter paper). The filtrate, evaporated to near dryness, is quantitatively transferred to a tared planchet and dried for gross beta counting. The filter paper containing the suspended activity is ashed in a muffle furnace at 600° C. and transferred to a planchet for gross beta counting.

Table 1. Beta and gamma efficiencies and detectability limits for the Washington State analysis

| Radionuclide | Energy band (MeV) | Efficiency (percent) | Average background (cpm) | Detectability limits (pCi) |
|---|---|---|---|---|
| Beta | | | | |
| Strontium-yttrium-90 | — | 33 | 0.5 | [a] 0.27 |
| Yttrium-90 | | 37 | 0.5 | [a] 0.24 |
| Phosphorus-32 | | 34 | 0.5 | [a] 0.26 |
| Gamma | | | | |
| Cesium-137 | 0.62-0.72 | 2.50 | 12.37 | [b] 30 |
| Chromium-51 | 0.30-0.36 | 0.45 | 25.03 | [b] 220 |
| Ruthenium-106 | 0.44-0.56 | 0.94 | 24.52 | [b] 100 |
| Zirconium-95 | 0.73-0.79 | 6.00 | 6.33 | [b] 10 |
| Zinc-65 | 1.05-1.17 | 0.94 | 6.92 | [b] 50 |

[a] Amount of radiation necessary to produce a net cpm equal to 2 sigma of background, based on 100-minute counts.
[b] Amount of radiation necessary to produce a net cpm equal to 4 sigma of the respective background, based on 100-minute counts.

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[1] Summarized from "Environmental Radiation Surveillance in Washington State, Fourth Annual Report, December 1965" (*1*).

Counting time is 100 minutes. After obtaining the net beta-counting rate, corrections for self absorption and efficiency are made and the results converted to concentrations in water. Gross beta results are not extrapolated to date of collection.

In addition to the above analyses, water samples from the Columbia River are also analyzed for phosphorus-32. The technique used for phosphorus-32 separation is a modification of published methods (*2–5*). After the sample has been stored for 15 days, which allows arsenic-76 and other short-lived interfering radionuclides to decay, the phosphorus is separated by precipitation as ammonium phosphomolybdate in an acid medium. The precipitate is washed with ammonium nitrate, dissolved with $3N$ ammonium hydroxide, transferred to a tared planchet, ashed, weighed, and counted for beta activity. The counting rate is corrected for self absorption, phosphorus-32 efficiency, and the decay rate. The results are converted to concentrations in water.

Beta counting is done with a low-background beta system including a 2-inch detector and automatic sample changer. This system has an average background of 0.5 counts per minute. Background counts are performed as an integral part of each sample. Gross beta calibration of the instrument is done with a strontium-yttrium-90 standard.

*Results*

Table 2 presents the monthly average results for the Columbia River stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to its numerical value and a less-than sign is placed in front of the average.

Table 3 summarizes the beta activity measurements from the 64 other surface water stations from July 1964 through June 1965. The second column in this table gives code numbers and the abbreviations denoting geographical sections (in figure 1). Each river is assigned a four-digit number; the first two digits indicate the river and the second two digits indicate the sampling stations on the river. For example, code number 04 refers to the Snake River in the area designated "RSE", i.e., Southeast. The code number 01 refers to the first sampling station on that river. The third column gives the total number of samples analyzed.

Gamma scans of the samples in table 3 indicated no detectable activity in any sample.

The network summary gives the maximum and minimum values for the 226 samples analyzed, while the network average is obtained by averaging all the station average values.

*Discussion*

Of the 226 river water samples analyzed from July 1964 through June 1965 (excluding the Columbia River), the total beta activity ranged from 1 to 24 pCi/liter with an average of 5.3 pCi/liter. The activity of the suspended fraction ranged from <1 to 11 pCi/liter with an average of <1 pCi/liter. The activity of the soluble fraction was slightly higher, ranging from <1 to 16 pCi/liter and averaging 4.3 pCi/liter. These network averages during the July 1964 through June 1965 period were lower by about a factor of two than the averages for the preceding 12 months.

Monthly average total beta activity for the Columbia River stations below the Hanford Facility ranged from 16 to 1,430 pCi/liter. Monthly average concentrations of the beta emitter, phosphorus-32, in the Columbia River water samples taken below the Hanford Facility ranged from 8 to 599 pCi/liter.

The gamma emitters ruthenium-106 and zirconium-95 were found in monthly average concentrations that ranged from <50 to 223 pCi/liter for ruthenium-106 and <5 to 22 pCi/liter for zirconium-95. The values for ruthenium-106 are probably a combination of ruthenium-103 and ruthenium-106. Two other radionuclides, chromium-51 and zinc-65, were found in detectable quantities in Columbia River water. Monthly averages for chromium-51 ranged from 326 to 18,719 pCi/liter and for zinc-65 the range was <25 to 708 pCi/liter.

Although any standards for gross beta activity must be very carefully applied, the standard for drinking water is 1,000 pCi/liter of beta activity, in the absence of strontium-90 and alpha emitters (*6*). The standards for water from all dietary sources for the general population at large (*7*) are, chromium-51, 670,000 pCi/liter; ruthenium-106, 3,300 pCi/liter; zirconium-95, 20,000 pCi/liter; zinc-65, 10,000 pCi/liter and phosphorus-32, 7,000 pCi/liter.

## Table 2. Beta activity in Washington surface water (except for Columbia River), July 1964–June 1965

| Sampling location | Code number | Number of samples | Concentrations, pCi/liter | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Suspended [a] | | | Dissolved [a] | | | Total | | |
| | | | Average | Minimum | Maximum | Average | Minimum | Maximum | Average | Minimum | Maximum |
| Baker River | RNW 0401 | 4 | 1 | <1 | 3 | 8 | 3 | 13 | 9 | 4 | 16 |
| Big Quilcene River | RPS 2201 | 2 | <1 | <1 | <1 | <1 | <1 | 1 | 1 | 1 | 2 |
| Bumping River | RSC 1001 | 1 | <1 | <1 | <1 | 3 | 3 | 3 | 4 | 4 | 4 |
| Cedar River | RPS 0201 | 12 | <1 | <1 | <1 | 2 | <1 | 3 | 2 | 1 | 4 |
| Chehalis River | RSW 0601 | 4 | <1 | <1 | <1 | 3 | 1 | 5 | 4 | 2 | 6 |
| | RCP 0401 | 4 | <1 | <1 | <1 | 2 | 2 | 3 | 3 | 3 | 4 |
| | | | | | | | | | | | 4 |
| Chico Creek | RPS 3101 | 3 | 1 | <1 | 2 | 6 | 4 | 7 | 7 | 5 | 9 |
| Cloquallam River | RCP 0101 | 6 | <1 | <1 | <1 | 2 | 1 | 4 | 3 | 2 | 5 |
| Colville River | RNE 0801 | 3 | <1 | <1 | 1 | 7 | 6 | 8 | 8 | 7 | 9 |
| Coweman River | RSW 0501 | 3 | <1 | <1 | <1 | 3 | 1 | 4 | 3 | 2 | 5 |
| Cowlitz River | RSW 0701 | 4 | 1 | <1 | 3 | 5 | 1 | 10 | 6 | 2 | 13 |
| Crab Creek | RSC 0102 | 1 | 2 | 2 | 2 | 16 | 16 | 16 | 18 | 18 | 18 |
| Deschutes River | RPS 1502 | 3 | <1 | <1 | <1 | [b] 3 | 2 | 4 | [b] 4 | 3 | 5 |
| Dosewallips River | RPS 2301 | 2 | <1 | <1 | <1 | 2 | 1 | 2 | 2 | 2 | 3 |
| Duckabush River | RPS 2401 | 2 | <1 | <1 | <1 | 6 | 1 | 11 | 7 | 2 | 12 |
| Dungeness River | RCP 0301 | 2 | <1 | <1 | <1 | 2 | 1 | 2 | 2 | 2 | 3 |
| Duwamish River | RPS 0601 | 4 | <1 | <1 | 2 | [b] 4 | 3 | 5 | [b] 5 | 4 | 6 |
| Elwha River | RCP 0201 | 2 | <1 | <1 | <1 | 2 | 1 | 3 | 3 | 2 | 4 |
| Goldsborough Creek | RPS 3001 | 2 | <1 | <1 | <1 | 2 | 1 | 3 | 3 | 2 | 4 |
| Green River | RPS 0501 | 4 | <1 | <1 | 1 | 3 | 1 | 5 | 3 | 2 | 6 |
| Hamma Hamma River | RPS 2601 | 2 | <1 | <1 | <1 | 6 | <1 | 12 | 7 | 1 | 13 |
| Hoh River | RCP 0801 | 2 | <1 | <1 | <1 | 3 | 2 | 3 | 3 | 3 | 4 |
| Humptulips River | RCP 0701 | 4 | <1 | <1 | <1 | 2 | <1 | 3 | 2 | 1 | 4 |
| Issaquah Creek | RPS 2901 | 3 | <1 | <1 | <1 | 2 | 2 | 3 | 3 | 3 | |
| Kalama River | RSW 0301 | 3 | <1 | <1 | <1 | 2 | 1 | 3 | 3 | 2 | 4 |
| Kettle River | RNE 0701 | 3 | <1 | <1 | <1 | 3 | 3 | 4 | 4 | 4 | 5 |
| Lake Washington | RPS 2801 | 3 | <1 | <1 | <1 | 8 | 6 | 9 | 8 | 7 | 10 |
| Little Spokane River | RNE 1001 | 8 | <1 | <1 | 2 | 5 | 3 | 7 | 6 | 4 | 8 |
| Newaukum River | RSW 0401 | 3 | <1 | <1 | <1 | 5 | 2 | 6 | 5 | 3 | 7 |
| Nisqually River | RPS 1401 | 3 | <1 | <1 | <1 | 7 | 2 | 9 | 7 | 3 | 10 |
| Nooksack River | RNW 0101 | 4 | 5 | <1 | 10 | 6 | 3 | 11 | 9 | 4 | 21 |
| N. Stillaguamish River | RPS 1601 | 4 | 2 | <1 | 5 | 5 | 2 | 9 | 7 | 3 | 14 |
| Pend Oreille River | RNE 0201 | 8 | <1 | <1 | <1 | 5 | 3 | 6 | 5 | 4 | 7 |
| | RNE 0203 | 3 | <1 | <1 | <1 | 5 | 4 | 7 | 6 | 5 | 8 |
| Puyallup River | RPS 1301 | 4 | 1 | <1 | 3 | 6 | 2 | 13 | 7 | 3 | 16 |
| Queets River | RCP 1301 | 2 | <1 | <1 | <1 | 3 | 2 | 3 | 3 | 3 | 4 |
| Quinault River | RCP 1401 | 2 | <1 | <1 | <1 | 3 | 2 | 4 | 4 | 3 | 5 |
| Samish River | RNW 0301 | 4 | 1 | <1 | 3 | 6 | 2 | 11 | 7 | 3 | 14 |
| Sammamish River | RPS 0701 | 4 | 2 | <1 | 3 | 6 | 4 | 7 | 8 | 5 | 10 |
| Sanpoil River | RNE 0901 | 3 | <1 | <1 | 1 | 3 | 2 | 4 | 3 | 3 | 5 |
| Satsop River | RCP 1201 | 4 | <1 | <1 | <1 | 1 | <1 | 2 | 2 | 1 | 3 |
| Skagit River | RNW 0201 | 4 | 2 | <1 | 3 | 6 | 3 | 10 | 7 | 4 | 12 |
| Skokomish River | RPS 2501 | 2 | <1 | <1 | <1 | 1 | <1 | 2 | 4 | 1 | 3 |
| Skykomish River | RPS 1101 | 4 | <1 | <1 | <1 | 4 | 2 | 5 | 2 | 3 | 6 |
| Snake River | RSE 0401 | 4 | 1 | 1 | 2 | 6 | 3 | 9 | 7 | 5 | 10 |
| | RSE 0402 | 2 | 5 | 2 | 8 | 8 | 7 | 8 | 13 | 10 | 15 |
| Snohomish River | RPS 0401 | 4 | <1 | <1 | 1 | [b] 5 | 2 | 10 | [b] 6 | 3 | 11 |
| Snoqualmie River | RPS 1201 | 4 | <1 | <1 | <1 | 4 | 3 | 4 | 4 | 4 | 5 |
| Soleduck River | RCP 0901 | 2 | <1 | <1 | <1 | 2 | 1 | 2 | 2 | 2 | 3 |
| S. Stillaguamish River | RPS 1001 | 4 | 2 | <1 | 4 | 6 | 3 | 10 | 7 | 4 | 14 |
| Spokane River | RNE 0301 | 8 | <1 | <1 | <1 | 4 | 2 | 6 | 5 | 3 | 7 |
| | RNE 0302 | 8 | 1 | <1 | 6 | 4 | 2 | 6 | 5 | 3 | 12 |
| Stillaguamish River | RPS 0301 | 4 | 4 | <1 | 11 | 6 | 2 | 13 | 9 | 3 | 24 |
| Sultan River | RPS 0901 | 4 | <1 | <1 | 1 | 5 | 3 | 9 | 6 | 4 | 10 |
| Teanaway River | RSC 0301 | 1 | <1 | <1 | <1 | 2 | 2 | 2 | 3 | 3 | 3 |
| Tolt River | RPS 2001 | 4 | <1 | <1 | 2 | 3 | 2 | 5 | 4 | 3 | 6 |
| Toutle River | RSW 0201 | 3 | <1 | <1 | <1 | 3 | 2 | 4 | 4 | 3 | 5 |
| Walla Walla River | RSE 0501 | 3 | 5 | 1 | 8 | 7 | 6 | 9 | 12 | 8 | 17 |
| Whatcom Lake | RNW 0601 | 3 | <1 | <1 | <1 | 6 | 5 | 7 | 7 | 6 | 8 |
| White River | RPS 0801 | 4 | 3 | <1 | 7 | 6 | 2 | 10 | 8 | 3 | 17 |
| Wynoochee River | RCP 0601 | 4 | <1 | <1 | <1 | 1 | <1 | 2 | 2 | 1 | 3 |
| Yakima River | RSC 0201 | 1 | <1 | <1 | <1 | 4 | 4 | 4 | 5 | 5 | 5 |
| | RSC 0202 | 1 | <1 | <1 | <1 | 5 | 5 | 5 | 6 | 6 | 6 |
| | RSE 0201 | 4 | <1 | <1 | 2 | 4 | 3 | 6 | 5 | 4 | 7 |
| Network summary | | 226 | <1 | <1 | 11 | 4.3 | <1 | 16 | 5.3 | 1 | 24 |

[a] For averaging purposes, <1 is assumed to be equal to 0.5. Averages less than one are recorded as <1.
[b] Sample contaminated in laboratory—not included in average.

## Table 3. Monthly average radioactivity in Columbia River water July 1964–June 1965

| Location and type of analysis | Concentrations, pCi/liter |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 1964 |  |  |  |  |  | 1965 |  |  |  |  |  |
|  | July | Aug | Sept | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | June |
| **Northport (code no. RNE 0601)** |  |  |  |  |  |  |  |  |  |  |  |  |
| Beta |  |  |  |  |  |  |  |  |  |  |  |  |
| Suspended [a] | NS | NS | NS | <1 | NS | <1 | NS | <1 | NS | NS | NS | NS |
| Dissolved [a] | NS | NS | NS | 8 | NS | 6 | NS | 4 | NS | NS | NS | NS |
| Total [a] | NS | NS | NS | <9 | NS | <7 | NS | <5 | NS | NS | NS | NS |
| Phosphorus-32 [b] | NS | NS | NS | <1 | NS | <1 | NS | <1 | NS | NS | NS | NS |
| Gamma [b] |  |  |  |  |  |  |  |  |  |  |  |  |
| Chromium-51 | NS | NS | NS | <110 | NS | <110 | NS | <110 | NS | NS | NS | NS |
| Ruthenium-106 [c] | NS | NS | NS | <50 | NS | <50 | NS | <50 | NS | NS | NS | NS |
| Zirconium-95 | NS | NS | NS | <5 | NS | <5 | NS | <5 | NS | NS | NS | NS |
| Zinc-65 | NS | NS | NS | <25 | NS | <25 | NS | <25 | NS | NS | NS | NS |
| **Richland (code no. RSE 0104)** |  |  |  |  |  |  |  |  |  |  |  |  |
| Beta |  |  |  |  |  |  |  |  |  |  |  |  |
| Suspended [a] | 15 | 121 | 71 | 754 | 22 | 27 | 20 | 28 | 569 | 71 | 277 | 328 |
| Dissolved [a] | 63 | 131 | 177 | 314 | 189 | 300 | 242 | 174 | 861 | 376 | 308 | 150 |
| Total [a] | 78 | 252 | 248 | 1,068 | 211 | 327 | 262 | 202 | 1,430 | 447 | 585 | 478 |
| Phosphorus-32 [b] | 60 | 151 | 143 | 396 | 231 | 396 | 298 | 191 | 533 | 292 | 437 | 154 |
| Gamma [b] |  |  |  |  |  |  |  |  |  |  |  |  |
| Chromium-51 | 2,647 | 7,949 | 8,406 | [d] 9,738 | 11,013 | 18,719 | 12,116 | 6,546 | [d] 8,010 | 11,711 | [d] 4,646 | [d] 1,337 |
| Ruthenium-106 [c] | <100 | <180 | 163 | [d] 223 | <120 | 156 | <143 | 110 | [d] <108 | 176 | [d] <100 | [d] <100 |
| Zirconium-95 | <10 | <16 | <10 | [d] 22 | <10 | <10 | <10 | <10 | [d] <12 | <14 | [d] <10 | [d] <10 |
| Zinc-65 | 101 | 526 | 302 | [d] 708 | 276 | 417 | 362 | 389 | [d] 551 | 671 | [d] 422 | [d] 170 |
| **Pasco (code no. RSE 0101)** |  |  |  |  |  |  |  |  |  |  |  |  |
| Beta |  |  |  |  |  |  |  |  |  |  |  |  |
| Suspended [a] | 8 | NS | 112 | 88 | 15 | 19 | 29 | 21 | 42 | 43 | 32 | 15 |
| Dissolved [a] | 26 | NS | 206 | 193 | 162 | 214 | 149 | 103 | 109 | 183 | 79 | 34 |
| Total [a] | 34 | NS | 318 | 281 | 177 | 233 | 178 | 124 | 151 | 226 | 111 | 49 |
| Phosphorus-32 [b] | 32 | NS | 112 | 50 | 224 | 278 | 98 | 117 | 133 | 303 | 102 | 45 |
| Gamma |  |  |  |  |  |  |  |  |  |  |  |  |
| Chromium-51 | 1,153 | NS | 16,995 | 4,341 | 10,289 | 2,807 | 8,518 | 4,436 | 5,022 | 8,117 | 2,610 | 1,900 |
| Ruthenium-106 [c] | <50 | NS | 183 | 222 | 101 | 87 | 76 | <52 | 83 | 93 | <50 | <50 |
| Zirconium-95 | <5 | NS | 12 | 20 | 7 | <5 | <5 | <5 | 8 | 6 | <5 | <5 |
| Zinc-65 | 64 | NS | 255 | 281 | 276 | 303 | 359 | 252 | 332 | 487 | 187 | 111 |
| **McNary Dam (code no. RSE 0102)** |  |  |  |  |  |  |  |  |  |  |  |  |
| Beta |  |  |  |  |  |  |  |  |  |  |  |  |
| Suspended [a] | NS | NS | 25 | NS | NS | 12 | NS | NS | 13 | NS | NS | 6 |
| Dissolved [a] | NS | NS | 48 | NS | NS | 89 | NS | NS | 49 | NS | NS | 10 |
| Total [a] | NS | NS | 73 | NS | NS | 101 | NS | NS | 62 | NS | NS | 16 |
| Phosphorus-32 [b] | NS | NS | 43 | NS | NS | 113 | NS | NS | 32 | NS | NS | 8 |
| Gamma |  |  |  |  |  |  |  |  |  |  |  |  |
| Chromium-51 | NS | NS | 5,242 | NS | NS | 6,251 | NS | NS | 2,139 | NS | NS | 326 |
| Ruthenium-106 [c] | NS | NS | 67 | NS | NS | <50 | NS | NS | <50 | NS | NS | <60 |
| Zirconium-95 | NS | NS | <5 | NS | NS | <5 | NS | NS | <5 | NS | NS | <6 |
| Zinc-65 | NS | NS | 72 | NS | NS | 139 | NS | NS | 96 | NS | NS | <30 |
| **Washougal (code no. RSW 0903)** |  |  |  |  |  |  |  |  |  |  |  |  |
| Beta |  |  |  |  |  |  |  |  |  |  |  |  |
| Suspended [a] | 13 | 12 | 8 | 8 | 8 | 12 | 13 | 17 | 14 | 43 | 12 | 10 |
| Dissolved [a] | 20 | 28 | 30 | 32 | 35 | 45 | 42 | 35 | 53 | 48 | 31 | 21 |
| Total [a] | 33 | 40 | 38 | 40 | 43 | 57 | 55 | 52 | 67 | 91 | 43 | 31 |
| Phosphorus-32 [b] | 19 | 18 | 13 | 23 | 36 | 50 | 39 | 37 | 63 | 63 | 40 | 28 |
| Gamma [b] |  |  |  |  |  |  |  |  |  |  |  |  |
| Chromium-51 | 1,212 | 2,631 | 3,259 | 3,426 | 3,010 | 2,884 | 2,391 | 2,323 | 2,372 | 2,354 | 1,177 | 1,023 |
| Ruthenium-106 [c] | <78 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 |
| Zirconium-95 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <7 | <5 | <5 | <5 | <5 |
| Zinc-65 | 67 | <36 | <25 | <29 | <25 | 53 | 56 | 90 | 194 | 106 | 56 | <50 |
| **Vancouver (code no. RSW 0102)** |  |  |  |  |  |  |  |  |  |  |  |  |
| Beta |  |  |  |  |  |  |  |  |  |  |  |  |
| Suspended [a] | 27 | 13 | 8 | 9 | 8 | 12 | 9 | 18 | 16 | 24 | 14 | 10 |
| Dissolved [a] | 23 | 29 | 29 | 31 | 35 | 42 | 41 | 30 | 45 | 46 | 28 | 21 |
| Total [a] | 50 | 42 | 37 | 40 | 43 | 54 | 50 | 48 | 61 | 70 | 42 | 31 |
| Phosphorus-32 [b] | 22 | 18 | 13 | [e] 20 | 31 | 49 | 46 | 35 | 59 | 60 | 40 | 24 |
| Gamma [b] |  |  |  |  |  |  |  |  |  |  |  |  |
| Chromium-51 | 1,339 | 2,526 | 3,434 | 3,447 | 2,808 | 2,710 | 2,359 | 2,299 | 2,209 | 2,332 | 1,191 | 1,022 |
| Ruthenium-106 [c] | <52 | <50 | <50 | <50 | <52 | <51 | <51 | <50 | <50 | <50 | <50 | <50 |
| Zirconium-95 | <6 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Zinc-65 | 75 | <45 | 27 | <32 | <41 | <54 | 57 | 88 | 94 | 116 | 54 | 45 |

[a] Activity at time of counting. $^{90}Sr$-$^{90}Y$ calibration standard in suspended and dissolved solids acidified.
[b] Results extrapolated to date of sample.
[c] Net activity in the 0.44–0.56 MeV gamma range is assumed to be only ruthenium-106.
[d] Scandium-46 contaminated sample not included in average.
[e] Contaminated sample not included in average.
NS, no samples collected.

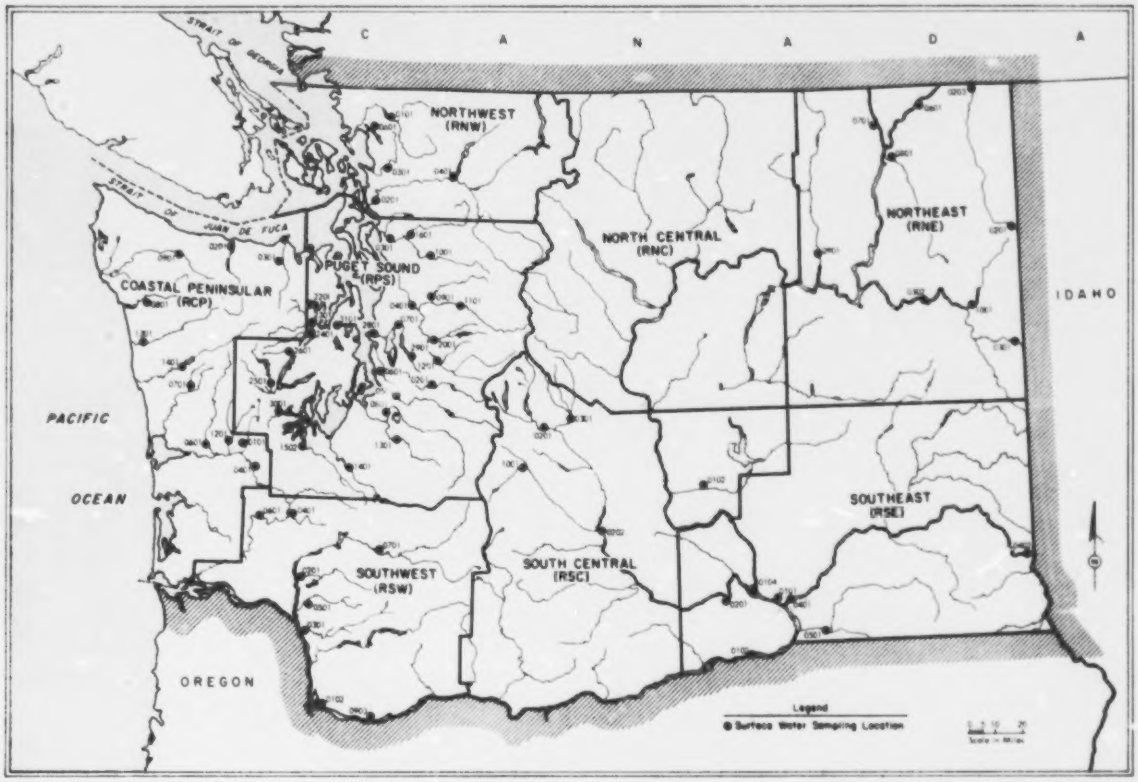
STRAIT OF GEORGIA
C A N A D A
NORTHWEST (RNW)
STRAIT OF JUAN DE FUCA
NORTH CENTRAL (RNC)
NORTHEAST (RNE)
PUGET SOUND (RPS)
COASTAL PENINSULAR (RCP)
IDAHO
PACIFIC
OCEAN
SOUTHEAST (RSE)
SOUTHWEST (RSW)
SOUTH CENTRAL (RSC)
OREGON
Legend
Surface Water Sampling Location
Scale in Miles

Figure 1. Washington surface water sampling locations

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(6) PUBLIC HEALTH SERVICE. Public Health Service drinking water standards, Revised 1962. PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (August 1963).

(7) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Report of Committee II on permissible dose for internal radiation. Pergamon Press, New York (1959).

Previous coverage in *Radiological Health Data:*

| *Period* | *Issue* |
|---|---|
| July 1962–June 1963 | August 1964 |
| July 1963–June 1964 | February 1965 |

# Section III. Air and Deposition

## RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to these programs presented in this issue, the results of other air and deposition programs have been previously covered in *Radiological Health Data and Reports:*

| Program | Period reported | Last presented |
|---|---|---|
| National Air Sampling Network | October–December and Annual Summary 1965 | April 1966 |
| Mexican Air Monitoring | November 1965 | March 1966 |

## 1. Radiation Surveillance Network
## January 1966

*Division of Radiological Health*
*Public Health Service*

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (2). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data*.

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during January 1966. Time profiles of gross beta in air dating back to 1958 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 298 air samples. No traces of fresh fission products were identified in these samples.

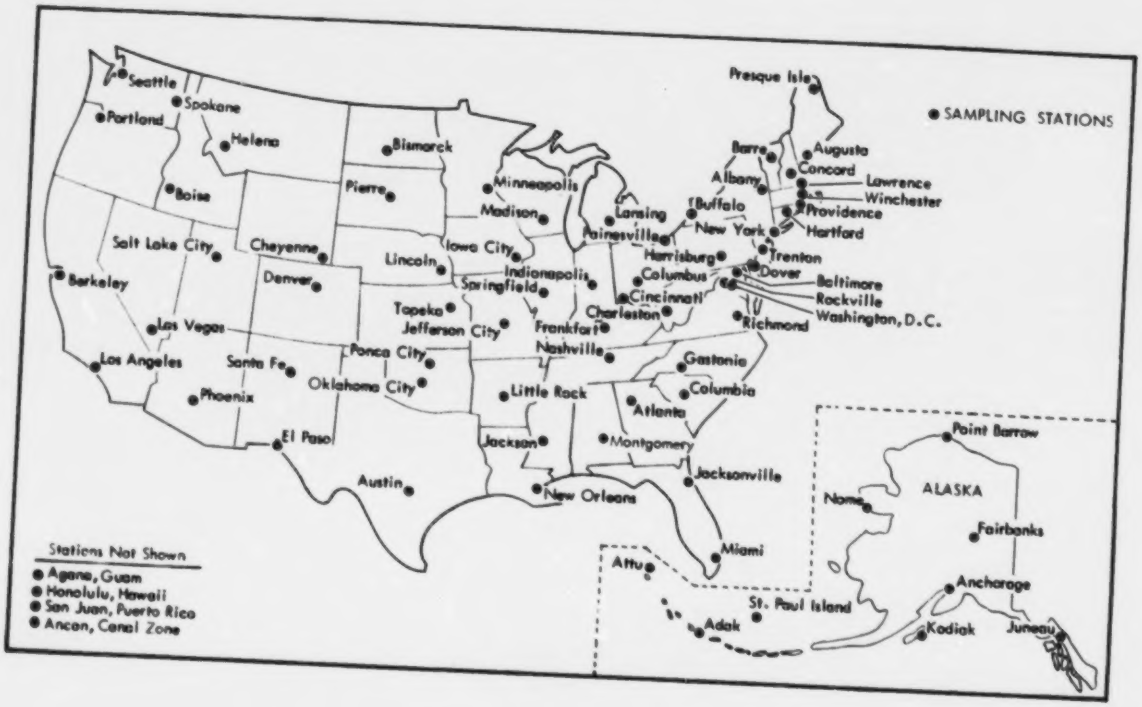

● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Salt Lake City
Berkeley
Las Vegas
Los Angeles
Phoenix
Cheyenne
Denver
Santa Fe
El Paso
Bismarck
Pierre
Lincoln
Topeka
Ponca City
Oklahoma City
Austin
Minneapolis
Madison
Iowa City
Springfield
Jefferson City
Little Rock
Jackson
New Orleans
Indianapolis
Lansing
Painesville
Columbus
Cincinnati
Frankfort
Nashville
Charleston
Montgomery
Atlanta
Jacksonville
Miami
Gastonia
Columbia
Presque Isle
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Providence
Buffalo
New York
Hartford
Harrisburg
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

## Table 1. Gross beta activity in surface air and precipitation, January 1966

| Station location | | Air surveillance | | | | | | Precipitation | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number of samples | | Gross beta activity, pCi/m³ | | | Last profile in RHD &R | Total depth (mm) | Total deposition (nCi/m²) |
| | | Air | Pptn | Maximum | Minimum | Average [a] | | | |
| Ala: | Montgomery | 31 | 8 | 0.13 | <0.10 | <0.10 | Feb 66 | 168 | <34 |
| Alaska: | Adak | 29 | | <0.10 | <0.10 | <0.10 | Sep 65 | (b) | |
| | Anchorage | 16 | 1 | 0.12 | <0.10 | <0.10 | Mar 66 | 2 | <0 |
| | Attu Island | 7 | | 0.24 | <0.10 | <0.13 | Oct 65 | (b) | |
| | Fairbanks | 5 | | <0.10 | <0.10 | <0.10 | Apr 66 | (b) | |
| | Juneau | 20 | 5 | 0.24 | <0.10 | <0.12 | July 65 | 95 | <19 |
| | Kodiak | 11 | | <0.10 | <0.10 | <0.10 | May 66 | (b) | |
| | Nome | 2 | | <0.10 | <0.10 | <0.10 | Dec 65 | (b) | |
| | Pt. Barrow | 28 | | <0.10 | <0.10 | <0.10 | Nov 65 | (b) | |
| | St. Paul Island | 13 | | <0.10 | <0.10 | <0.10 | Jan 66 | (b) | |
| Ariz: | Phoenix | 31 | | 0.16 | <0.10 | <0.11 | July 65 | (b) | |
| Ark: | Little Rock | 19 | 3 | <0.10 | <0.10 | <0.10 | Mar 66 | 66 | <13 |
| Calif: | Berkeley | 21 | 4 | 0.16 | <0.10 | <0.11 | May 66 | 116 | <23 |
| | Los Angeles | 21 | 1 | 0.13 | <0.10 | <0.10 | Dec 65 | 26 | <5 |
| C.Z: | Ancon | 16 | | <0.10 | <0.10 | <0.10 | May 66 | (b) | |
| Colo: | Denver | 30 | | 0.17 | <0.10 | <0.11 | May 66 | (b) | |
| Conn: | Hartford | 31 | 8 | <0.10 | <0.10 | <0.10 | Apr 66 | 45 | <9 |
| Del: | Dover | 18 | | <0.10 | <0.10 | <0.10 | Feb 66 | (b) | |
| D.C: | Washington | 28 | 6 | <0.10 | <0.10 | <0.10 | Nov 65 | 63 | <13 |
| Fla: | Jacksonville | 30 | 10 | 0.12 | <0.10 | <0.10 | Mar 66 | 121 | <24 |
| | Miami | 28 | 7 | 0.18 | <0.10 | <0.11 | Apr 66 | 90 | <18 |
| Ga: | Atlanta | (c) | 1 | | | | Jan 66 | 13 | <3 |
| Guam: | Agana | 31 | | 0.14 | <0.10 | <0.10 | Feb 66 | (b) | |
| Hawaii: | Honolulu | 30 | 3 | 0.12 | <0.10 | <0.10 | Oct 65 | 72 | <14 |
| Idaho: | Boise | 31 | 6 | 0.20 | <0.10 | <0.11 | Oct 65 | 25 | <6 |
| Ill: | Springfield | 26 | 1 | 0.12 | <0.10 | <0.10 | Nov 65 | 10 | <2 |
| Ind: | Indianapolis | 26 | 2 | <0.10 | <0.10 | <0.10 | Jan 66 | 85 | <17 |
| Iowa: | Iowa City | 28 | 4 | <0.10 | <0.10 | <0.10 | May 66 | 32 | <6 |
| Kans: | Topeka | 31 | 1 | <0.10 | <0.10 | <0.10 | Mar 66 | 8 | <2 |
| Ky: | Frankfort | 27 | 5 | 0.13 | <0.10 | <0.10 | Nov 65 | 32 | <6 |
| La: | New Orleans | 30 | 12 | 0.13 | <0.10 | <0.10 | Nov 65 | 353 | <71 |
| Maine: | Augusta | 31 | 13 | <0.10 | <0.10 | <0.10 | Dec 65 | 159 | <32 |
| | Presque Isle | 13 | | <0.10 | <0.10 | <0.10 | May 66 | (b) | |
| Md: | Baltimore | 20 | 4 | 0.13 | <0.10 | <0.10 | Apr 66 | 33 | <7 |
| | Rockville | 11 | | 0.19 | <0.10 | <0.12 | Oct 65 | (b) | |
| Mass: | Lawrence | 31 | 6 | 0.11 | <0.10 | <0.10 | Feb 66 | 77 | <15 |
| | Winchester | 29 | 13 | <0.10 | <0.10 | <0.10 | Sep 65 | 107 | <21 |
| Mich: | Lansing | 30 | | <0.10 | <0.10 | <0.10 | Oct 65 | (b) | |
| Minn: | Minneapolis | 21 | 8 | <0.10 | <0.10 | <0.10 | Feb 66 | 22 | <4 |
| Miss: | Jackson | 30 | 8 | 0.11 | <0.10 | <0.10 | Dec 65 | 148 | <30 |
| Mo: | Jefferson City | 28 | 2 | <0.10 | <0.10 | <0.10 | Jan 66 | 24 | <5 |
| Mont: | Helena | 30 | 8 | 0.17 | <0.10 | <0.11 | Sep 65 | 15 | <3 |
| Nebr: | Lincoln | 19 | | 0.21 | <0.10 | <0.12 | Jan 66 | (b) | |
| Nev: | Las Vegas | 27 | | 0.17 | <0.10 | <0.11 | Apr 66 | (b) | |
| N.H: | Concord | 19 | | <0.10 | <0.10 | <0.10 | Nov 65 | (b) | |
| N.J: | Trenton | 29 | 6 | <0.10 | <0.10 | <0.10 | Dec 65 | 25 | <5 |
| N.Mex: | Santa Fe | 28 | 3 | 0.12 | <0.10 | <0.10 | Sep 65 | 11 | <2 |
| N.Y: | Albany | 17 | 4 | <0.10 | <0.10 | <0.10 | Jan 66 | 26 | <5 |
| | Buffalo | 30 | | <0.10 | <0.10 | <0.10 | May 66 | (b) | |
| | New York | 21 | | <0.10 | <0.10 | <0.10 | Sep 65 | (b) | |
| N.C: | Gastonia | 28 | 10 | <0.10 | <0.10 | <0.10 | May 66 | 58 | <12 |
| N.Dak: | Bismarck | 29 | 4 | 0.11 | <0.10 | <0.10 | Nov 65 | 8 | <2 |
| Ohio: | Cincinnati | 19 | | <0.10 | <0.10 | <0.10 | Feb 66 | (b) | |
| | Columbus | 29 | 5 | 0.12 | <0.10 | <0.10 | Dec 65 | 83 | <17 |
| | Painesville | 30 | 7 | <0.10 | <0.10 | <0.10 | Apr 66 | 35 | <8 |
| Okla: | Oklahoma City | 30 | 5 | <0.10 | <0.10 | <0.10 | Oct 65 | 12 | <2 |
| | Ponca City | 21 | 3 | <0.10 | <0.10 | <0.10 | Apr 66 | 8 | <2 |
| Ore: | Portland | 31 | 22 | 0.21 | <0.10 | <0.11 | Jan 66 | 115 | <23 |
| Pa: | Harrisburg | 27 | 3 | <0.10 | <0.10 | <0.10 | Jan 66 | 16 | <3 |
| P.R: | San Juan | 27 | 4 | <0.10 | <0.10 | <0.10 | Dec 65 | 112 | <22 |
| R.I: | Providence | 29 | 3 | <0.10 | <0.10 | <0.10 | Oct 65 | 26 | <5 |
| S.C: | Columbia | 31 | 10 | 0.12 | <0.10 | <0.10 | Sep 65 | 143 | <29 |
| S.Dak: | Pierre | 30 | | <0.10 | <0.10 | <0.10 | July 65 | (b) | |
| Tenn: | Nashville | 27 | 11 | <0.10 | <0.10 | <0.10 | Oct 65 | 83 | <17 |
| Tex: | Austin | 28 | 9 | <0.10 | <0.10 | <0.10 | Feb 66 | 36 | <7 |
| | El Paso | 29 | 3 | 0.14 | <0.10 | <0.11 | Nov 65 | 8 | <2 |
| Utah: | Salt Lake City | 31 | 4 | 0.15 | <0.10 | <0.11 | Dec 65 | 15 | <3 |
| Vt: | Barre | 31 | 13 | <0.10 | <0.10 | <0.10 | Mar 66 | 49 | <10 |
| Va: | Richmond | 31 | 5 | <0.10 | <0.10 | <0.10 | Mar 66 | 52 | <10 |
| Wash: | Seattle | 31 | 17 | <0.10 | <0.10 | <0.10 | Mar 66 | 136 | <27 |
| | Spokane | 31 | 4 | <0.10 | <0.10 | <0.10 | Feb 66 | 17 | <3 |
| W.Va: | Charleston | 28 | 8 | <0.10 | <0.10 | <0.10 | Sep 65 | 92 | <18 |
| Wis: | Madison | 31 | 2 | <0.10 | <0.10 | <0.10 | Mar 66 | 30 | <6 |
| Wyo: | Cheyenne | 30 | 1 | 0.16 | <0.10 | <0.11 | Apr 66 | 2 | <0 |
| Network summary | | 1,848 | 316 | 0.24 | <0.10 | <0.10 | | 62 | <12 |

---

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the "<" values represent more than 10 percent of the average, a "less-than" sign is placed before the average.

[b] Indicates no precipitation sample collected.

[c] Indicates no report received.

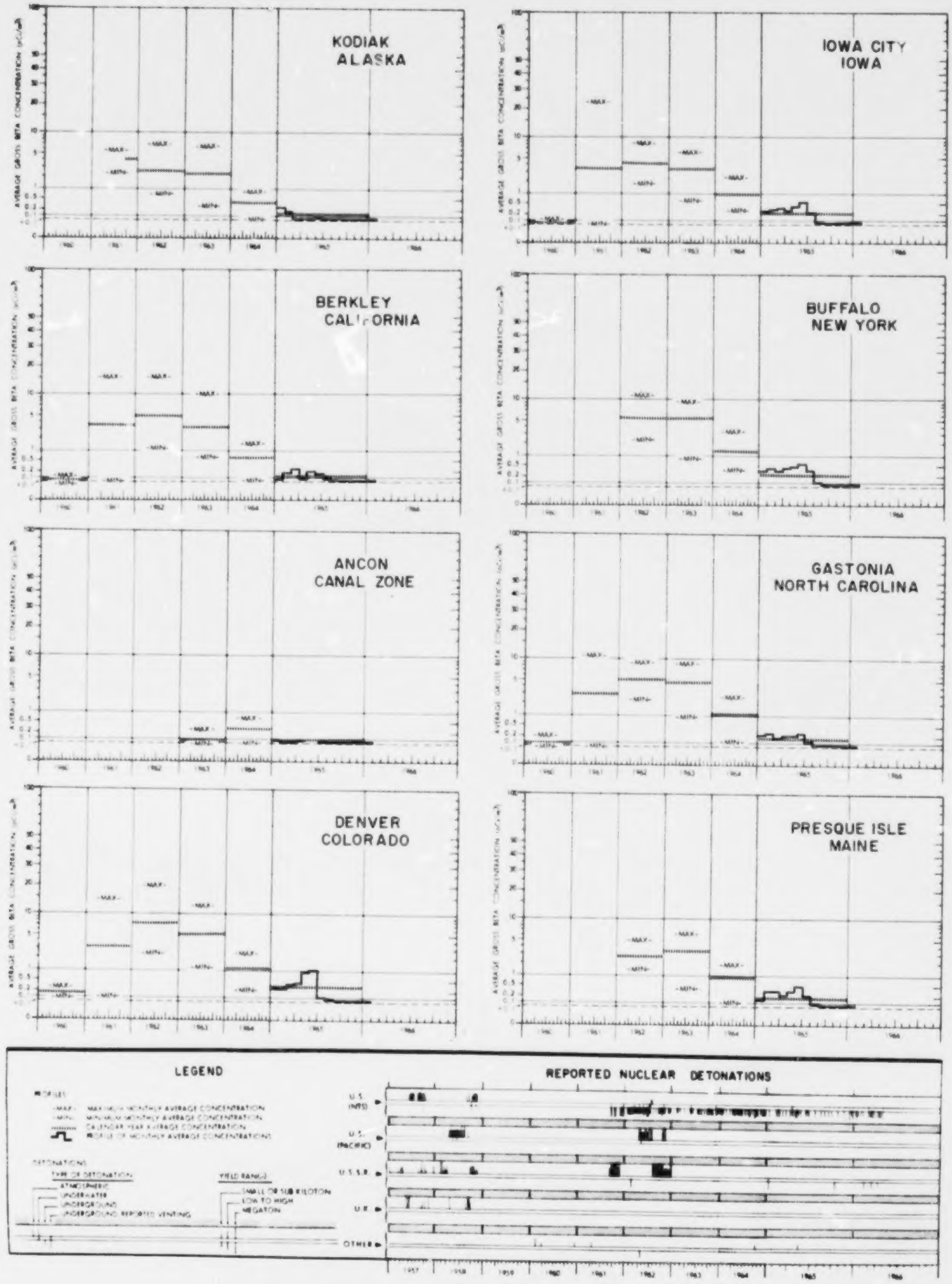


Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960–January 1966

## 2. Canadian Air and Precipitation Monitoring Program January 1966[1]

*Radiation Protection Division*
*Department of National Health and Welfare*
*Ottawa, Canada*

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

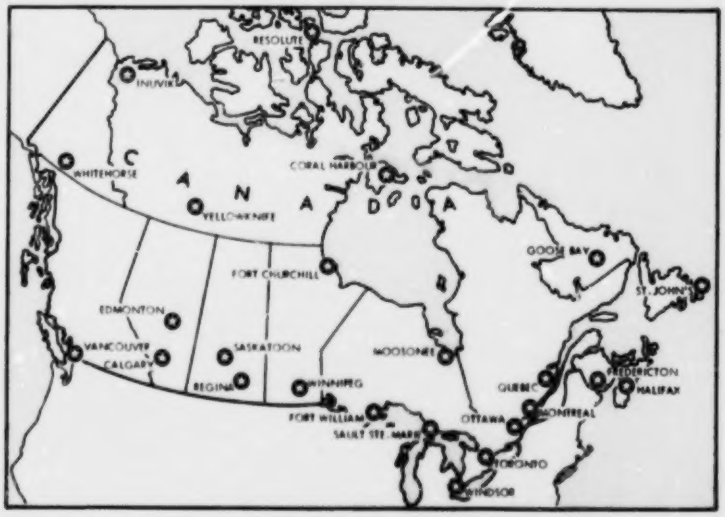
A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data* (*8*).

Surface air and precipitation data for January 1966 are presented in table 2.

**Table 2. Canadian gross beta activity in surface air and precipitation, January 1966**

| Station | Air Surveillance | | | | Precipitation measurements | |
|---|---|---|---|---|---|---|
| | Number of samples | Activity, pCi/m³ | | | Average concentration (pCi/liter) | Total deposition (nCi/m²) |
| | | Maximum | Minimum | Average | | |
| Calgary | 31 | 0.2 | 0.0 | 0.1 | 52 | 0.5 |
| Coral Harbour | 31 | 0.2 | 0.0 | 0.1 | 54 | 0.9 |
| Edmonton | 31 | 0.1 | 0.0 | 0.1 | 20 | 0.7 |
| Ft. Churchill | 31 | 0.1 | 0.0 | 0.1 | 24 | 0.3 |
| Ft. William | 25 | 0.1 | 0.0 | 0.1 | 27 | 1.1 |
| Fredericton | 31 | 0.1 | 0.0 | 0.1 | 16 | 1.2 |
| Goose Bay | 31 | 0.1 | 0.0 | 0.0 | 15 | 0.8 |
| Halifax | 31 | 0.1 | 0.0 | 0.1 | 34 | 3.2 |
| Inuvik | 31 | 0.2 | 0.1 | 0.1 | T | 0.3 |
| Montreal | 30 | 0.1 | 0.0 | 0.1 | 12 | 1.0 |
| Moosonee | 23 | 0.1 | 0.0 | 0.1 | 8 | 0.5 |
| Ottawa | 31 | 0.1 | 0.0 | 0.1 | 9 | 0.6 |
| Quebec | 31 | 0.1 | 0.0 | 0.1 | 14 | 2.1 |
| Regina | 31 | 0.2 | 0.0 | 0.1 | 64 | 1.0 |
| Resolute | 30 | 0.2 | 0.0 | 0.1 | 171 | 1.3 |
| St. John's, Nfld | 31 | 0.1 | 0.0 | 0.0 | 5 | 0.8 |
| Saskatoon | 31 | 0.2 | 0.0 | 0.1 | 29 | 0.5 |
| Sault Ste. Marie | 29 | 0.1 | 0.0 | 0.0 | 13 | 0.8 |
| Toronto | 31 | 0.1 | 0.0 | 0.1 | 22 | 1.3 |
| Vancouver | 31 | 0.1 | 0.0 | 0.0 | 27 | 3.1 |
| Whitehorse | 31 | 0.2 | 0.1 | 0.1 | 34 | 0.3 |
| Windsor | 31 | 0.2 | 0.0 | 0.1 | 37 | 0.8 |
| Winnipeg | 31 | 0.2 | 0.1 | 0.1 | 95 | 0.9 |
| Yellowknife | 31 | 0.1 | 0.1 | 0.1 | 22 | 0.2 |
| Network summary | | 0.1 | 0.0 | 0.1 | 35 | 1.0 |

T indicates trace


RESOLUTE
INUVIK
WHITEHORSE
C
A
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A
D
A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
SAULT STE. MARIE
OTTAWA
MONTREAL
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the February 1966 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

102

## 3. Pan American Air Sampling Program January 1966

*Pan American Health Organization and Public Health Service*

Gross beta activity in air is monitored by countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling stations are shown in figure 4.

The January 1966 air monitoring results from the participating countries are given in table 3.

**Table 3. Gross beta activity in surface air, January 1966**

| Station location | Number of samples | Gross beta activity, pCi/m³ | | |
|---|---|---|---|---|
| | | Maximum | Minimum | Average [a] |
| Argentina: Buenos Aires | 20 | 0.16 | <0.10 | <0.11 |
| Chile: Santiago | 17 | <0.10 | <0.10 | <0.10 |
| Jamaica: Kingston | 23 | <0.10 | <0.10 | <0.10 |
| Peru: Lima | 22 | <0.10 | <0.10 | <0.10 |
| Venezuela: Caracas | 21 | <0.10 | <0.10 | <0.10 |
| West Indies: Trinidad | 17 | <0.10 | <0.10 | <0.10 |
| Pan American summary | 120 | 0.16 | <0.10 | <0.10 |

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the "<" values represent more than 10 percent of the average, a "less-than" sign is placed before the average.

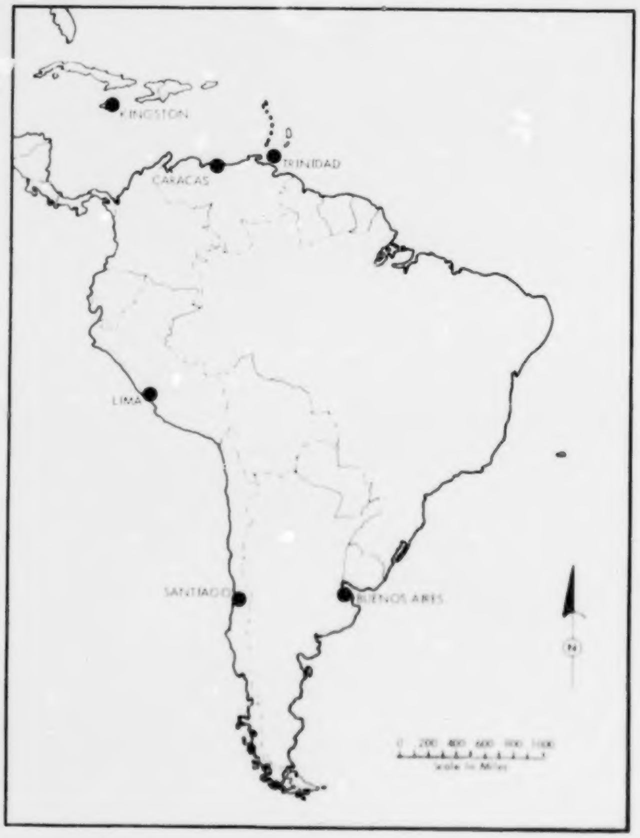

Figure 4. Pan American Air Network sampling stations

## 4. Fallout in the United States and other areas January–June 1965[1]

*Health and Safety Laboratory*
*Atomic Energy Commission*

Monthly fallout deposition rates for strontium-90 are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from all of the active United States stations and 35 other selected points in the Western Hemisphere (see figure 5) covering the period from January through June 1965 are summarized in tables 4 and 5. All the stations of the 80th Meridian Network, except Washington, D.C., are represented.

To facilitate the accurate storage, retrieval, and handling of data generated from the monthly fallout collections network, all data obtained are transcribed onto punched cards. To accomplish this transcription, several rigid criteria were applied to the data. One condition was that only monthly data are punched onto the cards. In the few cases where collections were incomplete or where collection times overlapped calendar months, the data were corrected to yield monthly values by interpolation using rainfall and observed concentrations in rainfall as guides. Where any corrections to the

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[1] The data in this article were taken from *Fallout Program Quarterly Summary Report*, HASL 165:2–202, Health and Safety Laboratory, AEC, New York, N.Y. 10014.

**Table 4. Strontium-90 fallout in the United States, HASL, January–June 1965**

| Sampling location and type of collection | | | Deposition, nCi/m² | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Jan | Feb | Mar | Apr | May | June |
| Ala: | Birmingham | (pot) | 0.27 | 0.05 | 0.95 | 0.54 | 0.38 | 0.84 |
| Alaska: | Anchorage | (col) | 0.06 | 0.63 | 0.19 | 0.05 | 0.02 | 0.24 |
| | Barrow | (col) | T | T | T | 0.01 | 0.02 | 0.03 |
| | Cold Bay | (col) | 0.02 | 0.19 | 0.64 | 0.19 | 0.42 | 0.79 |
| | Fairbanks | (col) | 0.04 | 0.02 | 0.14 | 0.11 | 0.07 | 0.55 |
| | Juneau | (col) | 0.42 | 0.37 | 0.38 | 0.53 | 0.60 | 0.56 |
| | Nome | (col) | NS | T | 0.02 | NS | * 0.03 | * 0.03 |
| Calif: | W. Los Angeles | (pot) | 0.76 | 0.08 | 0.35 | 1.21 | 0.15 | 0.63 |
| | Palo Alto | (pot) | 0.37 | 0.13 | 0.34 | 0.44 | 0.02 | 0.04 |
| | San Francisco | (col) | 0.42 | 0.10 | 0.37 | 0.58 | 0.01 | 0.01 |
| Colo: | Denver | (col) | 0.04 | 0.06 | 0.18 | 0.24 | 0.61 | 0.94 |
| Fla: | Coral Gables | (pot) | 0.18 | 0.28 | * 0.27 | * 0.27 | 0.15 | 0.19 |
| | Miami | (col) | 0.15 | 0.10 | 0.32 | 0.05 | 0.21 | 0.64 |
| Hawaii: | Hilo | (col) | 1.24 | 0.72 | 1.44 | 1.72 | NS | 2.68 |
| | Honolulu | (pot) | 0.29 | 0.50 | 0.52 | 0.02 | 0.14 | 0.01 |
| | Lihue | (col) | 0.30 | 0.34 | 0.32 | 0.45 | 0.57 | 0.33 |
| | Mauna Loa | (col) | 0.16 | 0.06 | 0.09 | 0.18 | 0.27 | 0.08 |
| Ill: | Argonne | (pot) | 0.42 | 0.17 | 0.08 | 0.78 | 0.38 | 0.68 |
| La: | New Orleans | (col) | 0.19 | 0.37 | 0.19 | 0.14 | 0.36 | 0.54 |
| Minn: | International Falls | (col) | T | 0.95 | 0.04 | 0.85 | 0.65 | 1.56 |
| Mo: | Columbia | (col) | 0.43 | 0.20 | 0.83 | 0.23 | 0.42 | 1.51 |
| Mont: | Helena | (col) | 0.05 | 0.05 | 0.15 | 0.22 | 0.71 | 1.13 |
| N.J: | Westwood | (pot) | 0.42 | 0.66 | 0.54 | 0.87 | 0.51 | 1.10 |
| N.Y: | New York | (pot) | 0.38 | 0.76 | 0.82 | 1.01 | 0.43 | 0.63 |
| N. Dak: | Williston | (col) | 0.09 | T | 0.02 | 0.31 | 1.11 | 0.71 |
| Ohio: | Wooster | (pot) | 0.51 | 0.09 | 0.08 | 0.80 | 0.08 | 0.40 |
| Okla: | Midwest City | (pot) | 0.14 | 0.54 | 0.15 | 0.55 | 1.22 | 1.10 |
| | Tulsa | (pot) | NS | NS | NS | NS | 3.80 | 0.41 |
| Ore: | Medford | (col) | 0.61 | 0.10 | 6.20 | 0.24 | 0.15 | 0.29 |
| S.C: | Columbia | (col) | 0.19 | T | 0.93 | 0.02 | 0.39 | 0.78 |
| S. Dak: | Vermillion | (pot) | 0.06 | 0.03 | 0.61 | 0.83 | 2.61 | 1.79 |
| Tenn: | Chattanooga | (pot) | 0.38 | 0.54 | 0.82 | 0.89 | 0.66 | 0.64 |
| Tex: | Dallas | (col) | 0.14 | 0.35 | 0.23 | 0.32 | 1.62 | 0.55 |
| | El Paso | (col) | 0.01 | 0.05 | 0.05 | T | 0.10 | 0.42 |
| | Houston | (col) | 0.09 | T | 0.39 | 0.50 | 0.83 | 0.63 |
| Utah: | Salt Lake City | (pot) | 0.52 | NS | 0.32 | 0.78 | 1.56 | 0.30 |
| Va: | Sterling | (col) | 0.20 | 0.29 | 0.51 | 0.73 | 0.61 | 0.59 |
| Wash: | Seattle | (pot) | 0.50 | 1.23 | 0.32 | 0.71 | 0.43 | 0.21 |
| | Seattle | (pot) | 0.56 | 0.36 | 0.01 | 0.45 | 0.44 | 0.29 |
| | Tatoosh Island | (col) | 0.50 | 1.13 | 0.37 | 0.85 | 0.32 | 0.05 |
| Wis: | Appleton | (pot) | 0.16 | 0.14 | 0.54 | 1.47 | 1.24 | 0.78 |
| | Green Bay | (col) | 0.13 | 0.13 | 0.32 | 1.07 | 1.04 | 0.27 |

* Proportioned from originally consolidated data.
NS, no sample reported.
T, zero or trace.

104

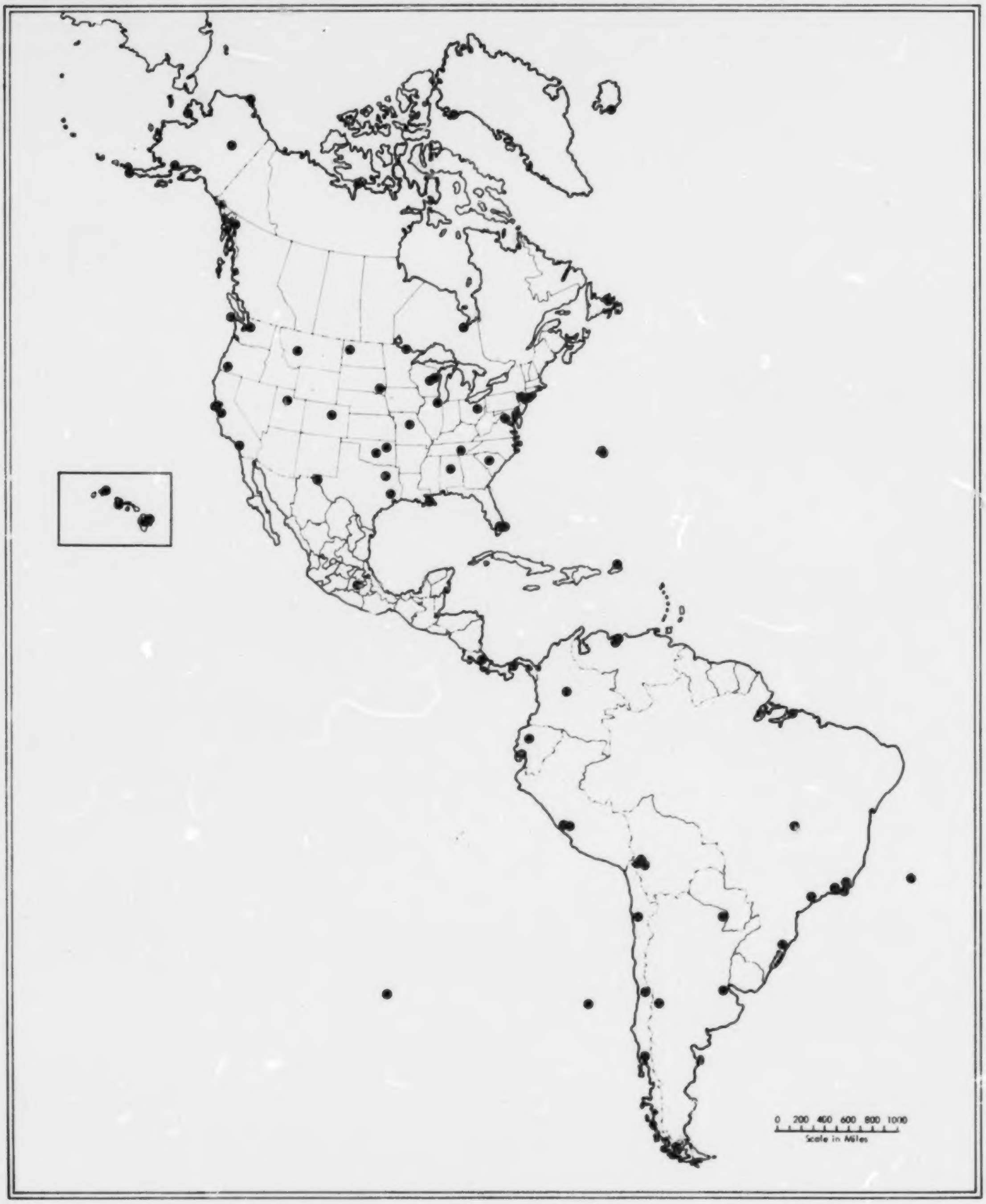
0 200 400 600 800 1000
Scale in Miles

**Figure 5. HASL fallout sampling stations in the Western Hemisphere**

**Table 5. Strontium-90 fallout in North and South America, HASL, January–June 1965**

| Sampling location and type of collection | | | Deposition in nCi/m² | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Jan | Feb | Mar | Apr | May | June |
| Argentina: | Buenos Aires | (col) | 0.18 | 0.31 | 0.09 | 0.09 | 0.04 | 0.07 |
| | Formosa | (col) | 0.11 | 0.20 | 0.06 | 0.11 | 0.06 | 0.03 |
| | Malargue | (col) | 0.37 | 0.07 | 0.10 | 0.08 | 0.12 | 0.32 |
| Bermuda: | Kindley AFB | (col) | 0.50 | 0.41 | 0.42 | 0.69 | 0.22 | 0.41 |
| Bolivia: | Chacaltaya | (col) | 0.08 | 0.06 | 0.02 | 0.02 | 0.01 | T |
| | La Paz (Ovejuyo) | (col) | 0.12 | 0.02 | 0.05 | 0.02 | 0.01 | 0.004 |
| | La Paz (city) | (col) | 0.08 | 0.03 | 0.07 | 0.02 | 0.01 | 0.01 |
| Brazil: | Belem | (col) | 0.13 | 0.14 | 0.08 | 0.17 | 0.06 | 0.08 |
| | Brasilia | (pot) | T | T | 0.01 | T | T | T |
| | Itaici Sao Paulo | (pot) | NS | [a] 0.07 | [a] 0.07 | NS | 0.05 | 0.02 |
| | Nova Friburgo | (pot) | NS | 0.15 | 0.10 | 0.08 | 0.03 | 0.02 |
| | Rio de Janeiro | (col) | 0.30 | 0.24 | 0.21 | 0.15 | 0.25 | 0.10 |
| | San Jose dos Campos | (pot) | 0.02 | 0.18 | 0.07 | 0.02 | 0.02 | NS |
| | Sao Leopoldo | (pot) | 0.25 | 0.09 | 0.20 | 0.09 | 0.06 | 0.16 |
| | Trindade Island | (col) | NS | NS | 0.22 | 0.02 | 0.17 | 0.05 |
| Canada: | Newfoundland | (col) | 0.12 | 0.04 | 0.04 | 0.08 | 0.08 | 0.55 |
| | Moosonee | (col) | 0.02 | 0.03 | 0.01 | 0.16 | 0.66 | 0.59 |
| Canal Zone: | Miraflores | (col) | T | 0.04 | 0.004 | NS | 0.12 | 0.70 |
| Chile: | Antofagasta | (col) | T | T | 0.004 | T | 0.004 | 0.03 |
| | I. Alejandro Selkirk | (col) | 0.13 | 0.05 | 0.17 | 0.15 | 0.45 | 0.03 |
| | Easter Island | (col) | 0.19 | 0.13 | 0.26 | 0.16 | 0.22 | 0.06 |
| | Puerto Montt | (col) | 0.29 | 0.32 | 0.09 | 0.25 | 0.27 | 0.19 |
| | Punta Arenas | (col) | 0.09 | 0.25 | 0.12 | 0.08 | 0.07 | NS |
| | Santiago | (pot) | 0.004 | T | 1.00 | 0.13 | 0.11 | 0.004 |
| | Santiago | (col) | 0.02 | 0.03 | 0.02 | 0.21 | 0.10 | 0.15 |
| Colombia: | Bogota | (pot) | 0.01 | NS | NS | 0.004 | [a] 0.02 | [a] 0.02 |
| Costa Rica: | Turrialba | (col) | 0.27 | 0.08 | 0.01 | 0.12 | 0.08 | 0.25 |
| Ecuador: | Guayaquil | (col) | 0.07 | NS | 0.10 | 0.10 | NS | NS |
| | Quito | (col) | 0.01 | 0.004 | 0.04 | 0.01 | 0.62 | 0.40 |
| Greenland: | Thule | (col) | 0.01 | 0.03 | 0.02 | 0.02 | 0.42 | 0.07 |
| Iceland: | Keflavik | (col) | 0.04 | 0.04 | 0.23 | 0.21 | 0.33 | 0.24 |
| Mexico: | Mexico City | (col) | [a] 0.03 | [a] 0.04 | 0.02 | 0.07 | 0.04 | 0.19 |
| Peru: | Lima | (col) | 0.04 | T | 0.02 | [a] 0.02 | [a] 0.02 | [a] 0.01 |
| | Lima | (col) | T | 0.01 | 0.04 | 0.02 | 0.03 | 0.02 |
| Puerto Rico: | San Juan | (col) | T | 0.02 | 0.11 | 0.26 | 1.22 | 0.99 |
| Venezuela: | Caracas (site 1) | (col) | 0.05 | 0.02 | 0.03 | 0.07 | 0.03 | 0.19 |
| | Caracas (site 2) | (col) | 0.05 | T | 0.05 | NS | NS | NS |

[a] indicates proportioned from originally consolidated data.
T, zero or trace.
NS, no sample reported.

data have been made, they are so indicated. In every case the best estimate of the true strontium-90 deposition is listed.

### *Other radionuclides*

Laboratories at Westwood, New Jersey; Chattanooga, Tennessee; Seattle, Washington; Appleton, Wisconsin; Palo Alto, California; and Midwest City, Oklahoma, have analyzed monthly pot samples for various radionuclides. The amount of precipitation at each station and the monthly deposition rates for strontium-89, strontium-90, cesium-137, cerium-144, zirconium-95, manganese-54, and iron-55 at each station are presented in table 6.

### *Methods of collection*

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless steel pot with an exposed area of 0.076 m². At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072 m², attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent-confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*1*).

106

Table 6. Radiochemical analyses of pot fallout samples at 6 U.S. sites, HASL fission product and "tracer" radionuclides in monthly collections, January-June 1965

| Sampling location | Precipitation, mm | | | | | | Strontium-89, nCi/m² | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | June | Jan | Feb | Mar | Apr | May | June |
| California, Palo Alto | 74.2 | 19.3 | 38.9 | 27.9 | T | T | 0.02 | 0.01 | NS | NS | NS | NS |
| New Jersey, Westwood | 64.0 | 77.2 | 39.6 | 46.0 | 34.0 | 49.8 | NS | NS | NS | NS | NS | NS |
| Oklahoma, Midwest City | 50.5 | 28.7 | 31.0 | 66.3 | 86.1 | 49.8 | <0.004 | 0.03 | NS | NS | NS | NS |
| Tennessee, Chattanooga | 82.8 | 119.4 | 254.0 | 98.6 | 71.1 | 107.7 | NS | NS | NS | NS | NS | NS |
| Washington, Seattle | 148.1 | 110.5 | 19.6 | 90.4 | 12.7 | 9.7 | NS | NS | NS | NS | <0.05 | 0.44 |
| Wisconsin, Appleton | 17.3 | [illegible] | 80.0 | 95.5 | 59.9 | 81.5 | NS | NS | NS | NS | NS | NS |
| | Strontium-90, nCi/m² | | | | | | Manganese-54, nCi/m² | | | | | |
| California, Palo Alto | 0.37 | 0.13 | 0.34 | 0.44 | 0.02 | 0.04 | 4.86 | 2.10 | 1.77 | 5.02 | 0.54 | 0.91 |
| New Jersey, Westwood | 0.42 | 0.06 | 0.54 | 0.87 | 0.51 | 1.10 | 4.05 | 6.68 | 3.94 | 5.29 | 4.44 | 5.29 |
| Oklahoma, Midwest City | 0.14 | 0.54 | 0.15 | 0.55 | 1.22 | 1.10 | 1.81 | 5.21 | 2.18 | 3.23 | 10.7 | 12.4 |
| Tennessee, Chattanooga | 0.38 | 0.54 | 0.82 | 0.89 | 0.06 | 0.64 | 3.81 | 3.39 | 4.63 | 4.86 | 4.94 | 3.33 |
| Washington, Seattle | 0.50 | 1.23 | 0.32 | 0.71 | 0.43 | 0.21 | 4.83 | 8.41 | 3.49 | 6.14 | 4.25 | 1.03 |
| Wisconsin, Appleton | 0.17 | 0.14 | 0.54 | 1.47 | 1.24 | 0.78 | 1.81 | 0.76 | 3.45 | 9.53 | 8.30 | NS |
| | Iron-55, nCi/m² | | | | | | Zirconium-95, nCi/m² | | | | | |
| California, Palo Alto | 5.06 | 1.85 | 3.57 | 4.28 | 1.12 | 1.10 | <0.004 | <0.004 | <0.03 | <0.03 | <0.09 | NS |
| New Jersey, Westwood | 4.86 | 7.10 | 4.94 | 4.48 | 4.55 | 6.95 | 0.16 | <0.04 | <0.03 | <0.06 | 0.35 | 0.82 |
| Oklahoma, Midwest City | 2.44 | 2.37 | 2.51 | 5.13 | 10.2 | 8.18 | <0.004 | <0.004 | <0.02 | <0.01 | 1.06 | NS |
| Tennessee, Chattanooga | 6.18 | 4.79 | 9.50 | 6.37 | 4.40 | 5.75 | <0.14 | <0.05 | <0.06 | <0.03 | 0.69 | 0.66 |
| Washington, Seattle | 3.56 | 10.3 | 4.59 | 7.57 | 4.44 | 2.04 | 0.01 | 0.02 | 0.02 | <0.02 | <0.01 | 0.60 |
| Wisconsin, Appleton | 1.91 | 1.62 | 4.52 | 8.26 | 6.76 | 5.02 | <0.12 | <0.19 | <0.02 | <0.04 | 2.73 | 0.36 |
| | Cesium-137, nCi/m² | | | | | | Cerium-144, nCi/m² | | | | | |
| California, Palo Alto | 0.45 | 0.19 | 0.46 | 0.54 | 0.06 | 0.08 | 1.71 | 0.59 | 1.31 | 1.52 | 0.17 | 0.24 |
| New Jersey, Westwood | 0.71 | 1.11 | 0.64 | 1.23 | 0.68 | 1.42 | 2.47 | 2.71 | 2.23 | 3.90 | 1.91 | 3.94 |
| Oklahoma, Midwest City | 0.20 | 0.68 | 0.24 | 0.65 | 1.56 | 1.48 | 0.67 | 1.93 | 0.84 | 1.79 | 3.85 | 4.28 |
| Tennessee, Chattanooga | 0.65 | 0.89 | 0.92 | 1.22 | 1.13 | 0.81 | 2.39 | 2.94 | 3.61 | NS | 2.57 | 2.83 |
| Washington, Seattle | 0.78 | 1.55 | 0.51 | 0.94 | 0.59 | 0.25 | 3.01 | 5.52 | 1.81 | 2.59 | 1.69 | 0.90 |
| Wisconsin, Appleton | 0.22 | 0.22 | 0.60 | 2.08 | 1.41 | 1.02 | 1.28 | 0.80 | 2.49 | 0.66 | 4.40 | 3.17 |

T, trace or zero
NS, no sample reported

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(2) RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. Division of Radiological Health, Public Health Service, Washington, D.C. 20201 (distribution by official request).

(3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program. CNHW–RP–3, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(4) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program. CNHW–RP–4, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(5) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program. CNHW–RP–5, Department of National Health and Welfare, Ottawa, Canada (December 1962).

(6) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program. RPD–11, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(7) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada. RPD–21, Department of National Health and Welfare, Ottawa, Canada (August 1962).

(8) CANADIAN DEPARTMENT OF NATIONAL HEALTH AND WELFARE. Canadian air and precipitation monitoring, August 1965. Rad Health Data 6:671–672 (December 1965).

# Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

## ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Lawrence Radiation Laboratory and the Mound Laboratory.

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[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

### 1. Lawrence Radiation Laboratory January–June, 1965[2]

*University of California*
*Berkeley, California*

*Berkeley Site*

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located to the east of the University of California campus (figure 1). Technical facilities include a 6.3-BeV proton accelerator (Bevatron), a 700-MeV cyclotron, a 10-MeV linear accelerator, an 88-inch cyclotron, and various chemistry and physics laboratories.

The environmental sampling program includes monitoring of the atmosphere, surface and ground waters, sewage, and rain or dry deposition. Three types of atmospheric samples are taken: stack samples, local area samples, and perimeter samples.

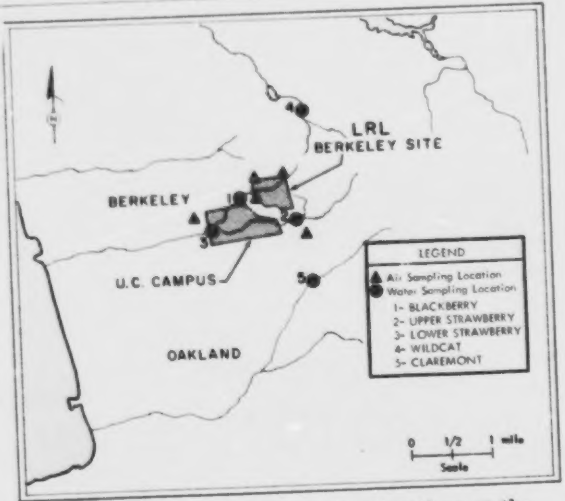

Figure 1. Environmental sampling locations at the Berkeley site

Approximately 110 "stacks" with potential for releasing radioactive contaminants are sampled continuously. One-inch-diameter filters are used at a flow rate of 1 liter per minute. The filters are changed weekly and counted for beta activity by an end-window Geiger-Mueller tube and for alpha activity by a thin-window proportional counter. Local area and perimeter air samples are taken at locations on the Laboratory site and at the property line, respectively. The samples are taken on 4- by 9-inch HV-70 filter paper at 4 cfm. The filters are changed weekly, counted for alpha activity by a thin-window proportional counter, and for beta activity by a 30 mg/cm²-window Geiger-Mueller tube. A 40 percent loss in the alpha count is assumed for self absorption. The average levels of activity observed in each type of sample are given in table 1.

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[2] Summarized from "Results of Environmental Radioactivity Sampling Program," Lawrence Radiation Laboratory, first half 1965.

**Table 1. Atmospheric monitoring, Berkeley site January–June 1965**

| Sampling locations | Number of samples | Average concentrations (pCi/m³) | |
|---|---|---|---|
| | | Alpha | Beta |
| Stacks | 1,000 | ND | 3.54 |
| Local area | 242 | ND | 0.37 |
| Perimeter | 97 | ND | 0.40 |

ND, not detectable

Rain or deposition samples are collected monthly in 18-inch diameter cylindrical vessels lined with polyethylene bags at local area and perimeter sites. Rain samples are poured out and evaporated in beakers. If the bag is dry, it is rinsed out with dilute nitric acid, and the resulting solution is then evaporated. Final evaporation is conducted in 2-inch diameter stainless-steel planchets, which are then flamed and coated with a thin film of lacquer. These planchets are counted for alpha activity in an internal-flow proportional counter and for beta activity with a thin-window, low-background Geiger-Mueller flow counter. No correction is made for self-absorption in the sample. Deposition data are given in table 2.

**Table 2. Total deposition, Berkeley site January–June 1965**

| Location | Number of samples | Average concentrations (pCi/m²) | |
|---|---|---|---|
| | | Alpha | Beta |
| Local area | 60 | 0.093 | 23.16 |
| Perimeter | 23 | 0.093 | 22.00 |

Water samples are taken from sewers, onsite streams, and offsite streams. Two sewer lines serve the LRL area. The "Hearst" sewer receives waste from the larger part of the area. A sampling system takes a continuous proportional sample from the Hearst sewer as it leaves the Laboratory boundary. Samples are also taken of waste feeding into the Hearst sewer from Buildings 70, 70A, and 71. The "Strawberry" sewer receives waste from the southeast part of the Laboratory site. A monitoring station for this sewer is under construction but has not yet been put into operation. Building 74 is the most likely contributor of radioactivity to this sewer line. The two acid waste systems from Building 74 are sampled individually on a continuous basis. Values reported for the Strawberry sewer are those obtained from Building 74. Strawberry and Blackberry Creeks comprise the Laboratory's storm drainage. These are sampled weekly at three locations. Two other nearby offsite streams are also sampled weekly. All water samples are handled in the same manner as rain samples. The results from the water sampling program are presented in table 3.

**Table 3. Water monitoring, Berkeley site January–June 1965**

| Type of sample | Number of samples | Average concentration (pCi/liter) | |
|---|---|---|---|
| | | Alpha activity | Beta activity |
| Sewage: | | | |
| Hearst sewer | 65 | 0.73 | 22.2 |
| Strawberry sewer | 47 | 0.24 | 26.6 |
| Tap water | 24 | 0.04 | 4.6 |
| Surface water: | | | |
| Onsite streams | 74 | 1.5 | 13.7 |
| Offsite streams | 50 | 1.2 | 4.4 |

## *Livermore Site*

The Livermore site of LRL (see figure 2) is located about 50 miles southeast of San Francisco, California. Technical facilities include a small cyclotron, a 2-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

An environmental sampling program is maintained to provide information regarding the

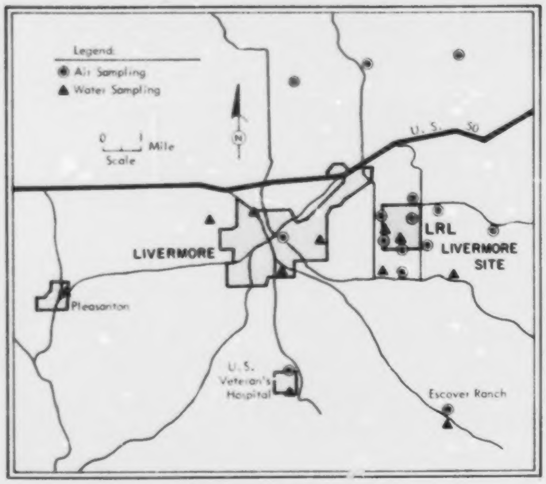

Figure 2. Sampling locations at the Livermore site

effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, and sewage plant products. Air samples are collected to ascertain that control efforts are restricting the release of radioactivity from the Laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 15 sites within 5 miles of the Laboratory. Samples are collected at a rate of 4 cfm on 4- by 9-inch HV–70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. The alpha activity remaining is measured in a gas flow proportional counter with a counting efficiency of about 28 percent for 5.1 MeV alpha particles. The beta activity is measured in the same instrument using a strontium–90 in equilibrium with yttrium–90 source as the standard. The efficiency for beta particles is about 35 percent. Alpha activity in 357 air samples averaged 0.001 pCi/$m^3$, while beta activity averaged 0.17 pCi/$m^3$.

Domestic water samples are collected monthly from nine nearby areas. The alpha activity fluctuated from the limit of sensitivity (5.0 pCi/liter) to a high of 20.9 pCi/liter. The beta activity ranged from the limit of sensitivity (1.8 pCi/liter) to 105 pCi/liter. The average alpha concentration was 5.6 pCi/liter and the average beta concentration was 11.6 pCi/liter. The gas proportional counter used in these measurements has a counting efficiency of 34 percent for alpha emitters and 50 percent for beta emitters.

Samples are collected every Monday, Wednesday, and Friday at the sewer line leaving the southwest project boundary, where it connects with the Livermore domestic sewer line. Grab samples are collected monthly at the Livermore Sewage Disposal Plant to assure that the liquid effluent from the laboratory is not creating abnormal radioactivity concentrations either in the oxidation ponds (which overflow into a natural waterway) or in the dried sludge (which is used as an agricultural soil conditioner). Radioactivity levels in sewage oxidation ponds and dried sludge are summarized in table 4.

**Table 4. Environmental sampling, Livermore January–June 1965**

| Type of sample | Average concentration | |
|---|---|---|
| | Alpha activity | Beta activity |
| Sewage (pCi/liter) | 20 | 146 |
| Oxidation ponds (pCi/liter) | 39 | 77 |
| Dried sludge (pCi/g) | 39 | 41 |

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha activity fluctuated from the minimum detectable level (1.5 pCi/g) to 13.0 pCi/g. The beta activity fluctuated from the minimum detectable level (3.5 pCi/g) to 53.0 pCi/g. The average alpha concentration was 2.4 pCi/g and the average beta concentration was 16.1 pCi/g. The concentrations are in the normal range for soil in the Livermore Valley.

*Site 300*

Site 300 (see figure 3), is located in a very

110

sparsely populated ranching area about 17 miles southeast of the Lawrence Radiation Laboratory at Livermore. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on an irregular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from six onsite wells because they are the only readily accessible sources of underground water. Samples are collected from streams only during the winter months, when water flow exists. Soil samples are collected monthly at nine offsite locations. Only top layer soil is collected to determine fallout concentrations. All air, water, and soil samples are processed at the Laboratory in Livermore. The average radioactivity levels in all types of samples are summarized in table 5.

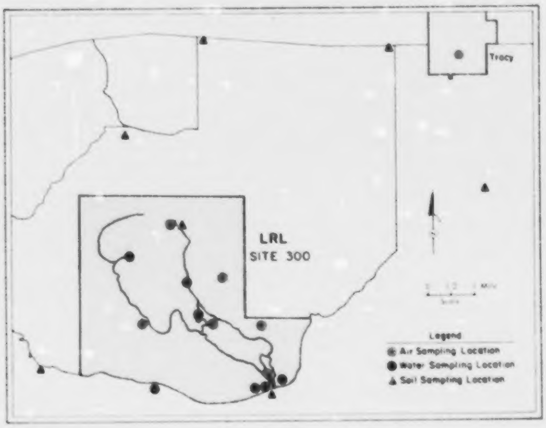

Figure 3. Sampling locations at Site 300, Lawrence Radiation Laboratory

Table 5. Environmental sampling, Site 300
January–June 1965

| Type of sample | Average concentration | |
|---|---|---|
| | Alpha activity | Beta activity |
| Air (pCi/m³) | 0.001 | 0.15 |
| Water (pCi/liter) | ND | 13 |
| Soil (pCi/g) | 5 | 10 |

ND, not detectable

Previous coverage in *Radiological Health Data and Reports:*

| *Period* | *Issue* |
|---|---|
| July-December 1961 | October 1962 |
| Calendar Year 1962 | October 1963 |
| Calendar Year 1963 | October 1964 |
| January-June 1964 | May 1965 |
| July-December 1964 | November 1965 |

## 2. Mound Laboratory
## January–June 1965[3]

*Monsanto Research Corporation*
*Miamisburg, Ohio*

Of the radionuclides in use at Mound Laboratory, only polonium–210, plutonium–239, and hydrogen–3 (tritium) are potential environmental contaminants. No measurable amounts of penerating radiation such as gamma or hard beta have been contributed to the environment by the Laboratory during the period covered by this report.

The environmental monitoring program, conducted by the Monsanto Research Corporation, is planned and coordinated with regard to all of the various projects performed in the Laboratory. Air and water monitoring methods and results are discussed below.

### *Air monitoring*

A continuous air monitor for measurement of tritium, and particulate air-sampling equipment for measurement of alpha activity, are mounted on a 1-ton panel truck for use in the routine monitoring of the environmental air at 90 locations selected within a radius of 20 miles. The choice of sites on a given day depends on the wind direction at the time of collection.

During the 6-month period ending June 1965, 319 samples were taken for determination of tritium in air. In all cases tritium was nondetectable.

Monitoring for possible polonium–210 and plutonium–239 released to the environment is accomplished by determination of long-lived gross alpha activity of filter paper samples. Counting is done in a low-background proportional counter. Sufficient delay time is allowed after collection to minimize interference from the daughter products of radon and thoron. The measured concentrations of alpha activity in air are summarized in table 6. Since the gross alpha activity remained substantially below the environmental limits for these nuclides, specific determinations of polonium-210 or plutonium-239 were not made.

---

[3] Summarized from "Environmental Monitoring Report: January–June 1965" (MLM–1275).

**Table 6. Long-lived alpha concentrations in air in the Mound Laboratory environment, January–June 1965**

| Direction from laboratory relative to wind | Number of samples | Average concentration (pCi/m³) |
|---|---|---|
| Upwind | 52 | 0.0036 |
| Downwind | 31 | 0.0028 |

## *Water monitoring*

Liquid radioactive waste materials from polonium and plutonium operations at the Laboratory are processed in special waste disposal plants designed to reduce radioactivity to a concentration level at which it may be discharged to the Great Miami River.

Helium-3, which is purified at the Mound Laboratory, contains small quantities of tritium. Liquid waste from this work, small in volume, is treated (diluted with water when necessary) to assure that the radioactivity content is below the maximum permissible concentration before discharge to the Great Miami river.

Weekly water samples are collected from a drainage ditch and five locations along the Great Miami river as shown in figure 4. Additional samples are taken quarterly at distant downstream points. The drainage ditch carries away all storm sewer water and liquid tritium and treated plutonium wastes from the plant site. Sampling location number 2 is located at the point of discharge of the laboratory effluent to the Great Miami River, and number 6 is 5 miles downstream from the effluent outlet.

All of the river samples are analyzed for polonium-210. The drainage ditch samples and some of the river samples are analyzed for tritium. The drainage ditch samples are also analyzed for plutonium-239. Average concentrations of tritium, polonium-210, and plutonium-239 are given in table 7.

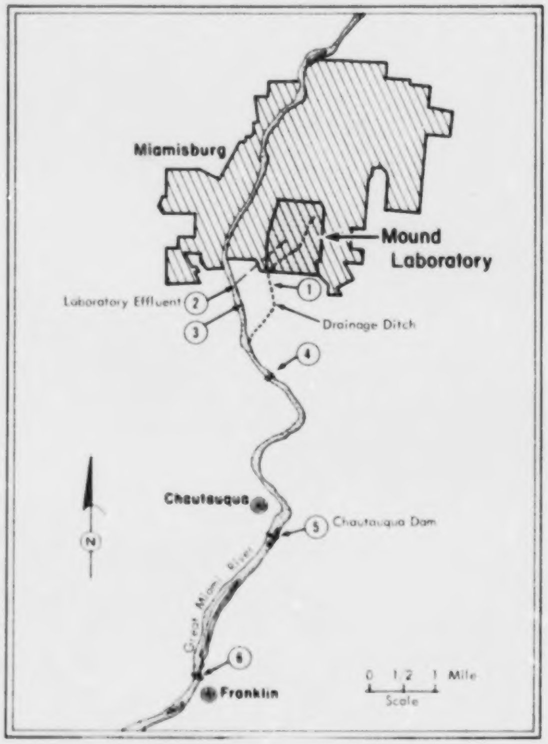

**Figure 4. Water sampling locations in Great Miami River, Mound Laboratory**

**Table 7. Offsite water monitoring for polonium-210, tritium, and plutonium-239 from Mound Laboratory, January–June 1965**

| Nuclide and sampling station | Number of samples | Average concentration (pCi/liter) |
|---|---|---|
| Polonium-210 | | |
| 2 (effluent) (see figure 3) | 21 | 7.2 |
| 3 (250 yards downstream) | 21 | 1.8 |
| 4 | 21 | 0.4 |
| 5 | 21 | 1.4 |
| 6 | 21 | 0.9 |
| Trenton, Ohio | 2 | 0.4 |
| New Miami, Ohio | 2 | 0.9 |
| 7 miles upstream from New Baltimore, Ohio | 2 | 0.9 |
| New Baltimore, Ohio | 2 | 0.9 |
| Miamitown, Ohio | 2 | 0.0 |
| Elizabethtown, Ohio | 2 | 0.4 |
| Hydrogen-3 (tritium) | | |
| 1 (drainage ditch) | 21 | 300,000 |
| 2 (effluent) | 21 | <100,000 |
| 4 | 21 | <100,000 |
| Plutonium-239 | | |
| 1 (drainage ditch) | 22 | 208 |

Previous coverage in *Radiological Health Data:*

| *Period* | *Issue* |
|---|---|
| January-June 1962 | March 1963 |
| July 1962–June 1963 | April 1964 |
| July-December 1963 | November 1964 |
| January-June 1964 | May 1965 |
| July-December 1964 | November 1965 |

112

# Section V. Technical Notes

## REPORTED NUCLEAR DETONATIONS, APRIL 1966

Five U.S. underground nuclear tests at the Nevada Test Site (NTS) were announced by the Atomic Energy Commission during April 1966. Tests of low yield (equivalent to the force of less than 20 kilotons of TNT) were conducted on April 1, 6, 7, and 25; and a test of low-intermediate yield (equivalent to the force of 20 to 200 kilotons of TNT) was conducted on April 14.

The Commission also announced that the United States has recorded seismic signals which originated in the Soviet nuclear testing area in the Semipalatinsk Region. The signals were equivalent to those of a nuclear test in the low-yield range.

Preliminary information from the NTS surveillance system indicates that a small amount of radioactive material was detected offsite following two 1966 underground nuclear tests. An underground test conducted on March 5 released radioactivity to the atmosphere that was just detectable in the nearby offsite populated area by external gamma monitoring and in ground-level air filter samples. Observations on the test of April 25 showed measurable amounts of radioactivity on the ground and in milk to the northeast of the site. This prompted AEC to recommend that some milk cows in the area be put on dry feed for about 16 days. Subsequent measurements of radioactivity in the thyroid glands of 71 children and 9 adult residents in nearby villages resulted in total dose estimates ranging from 50 to 100 millirads for 14 individuals, to a maximum of 250 to 300 millirads for 5 individuals, based on iodine present in their thyroid glands at the time of measurement. Additional intake of iodine–131 was expected from milk consumed after the time of thyroid counting, but this would not greatly increase the total thyroid dose.

## SYNOPSES

**Synopses of reports are presented below for reference card format for the reader's convenience.**

DISPOSAL OF RADIOACTIVE WASTES FROM U.S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES. *J. W. Vaughan* and *M. E. Miles* (Department of the Navy). ***Radiological Health Data and Reports, Vol. 7, May 1966***, pp. 257–262.

This report summarizes data on disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities and summarizes results of environmental monitoring performed to confirm adequacy of waste disposal limits and procedures. The waste disposal data presented show that the total long-lived radioactivity in liquid waste discharges associated with operation and maintenance of Naval nuclear-powered ships has been less than 2 curies per year in any harbor. Results of environmental surveys of harbor water and bottom sediment for gross radioactivity and for cobalt–60 have shown that (1) no increase in radioactivity above normal background levels has been detected in harbor water, (2) discharges of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase in the general background radioactivity of the environment, and (3) low-level cobalt–60 radioactivity has been detected in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards where maintenance and overhaul of Naval nuclear-powered ships has been conducted over a period of several years.

This report confirms that procedures issued by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the health and safety of the general public. These Navy procedures, which have been reviewed and concurred in by the U.S. Public Health Service and the U.S. Atomic Energy Commission, contain discharge limits which are consistent with applicable recommendations of the Federal Radiation Council, U.S. Atomic Energy Commission, and International Commission on Radiological Protection.

KEY WORDS: cobalt–60, environmental survey, harbors, liquid wastes, nuclear-powered ships, radioactivity, sediments, support facilities, waste disposal.

THE GALVESTON ENVIRONMENTAL SURVEILLANCE PROGRAM. *D. H. Flora* and *M. C. Wukasch* (Texas State Department of Health). ***Radiological Health Data and Reports***, Vol. 7, May 1966, pp. 263–267.

Environmental surveillance between March 10 and August 20, 1965, at the Galveston refueling and servicing site for the Nuclear Ship Savannah indicated no detectable radioactive contamination attributable to the ship's operations. Surveillance activities, which have continued at this site since July 1962, include air, rain, seawater, silt, shellfish (oysters), and milk sampling. During the Savannah's 1965 visit, almost all analytical results for environmental samples were close to or below detectable limits, except for milk. Radioactivity trends in milk samples at this time closely followed the nationwide trend reported by the U.S. Public Health Service.

KEY WORDS: air, alpha, barium–140, beta, cesium–137, environmental, Galveston, gamma, iodine–131, milk, nuclear ship, radionuclides, rain, seawater, silt, U.S. Savannah, strontium–89, strontium–90, Texas.

# RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 6 June 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

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## CONTENTS

## REPORTS

Page

Colorado Dental X-ray Machine Survey, 1961–April 1965 — 319
*R. W. Alcox, R. A. Downs,* and *P. W. Jacoe*

Radioactivity in Milk in the United Kingdom, 1962–1965 — 326
*R. S. Bruce*

Radionuclides in the United Kingdom Diet, 1962–1964 — 331
*R. S. Bruce*

## DATA

SECTION I. MILK AND FOOD — 335

National and International Milk Surveillance — 336
(including list of other programs previously reported)

1. Pasteurized Milk Network, February 1966, *PHS* — 336
2. Canadian Milk Network, February 1966 — 339
3. Pan American Milk Sampling Program, February 1966, *PAHO* and *PHS* — 340
4. Radiostrontium in Milk, July–December 1965, *AEC* — 340

State Milk Surveillance Activities — 343
(including list of other State programs previously reported)

1. California Milk Network, October–December 1965 and Annual Summaries 1964 and 1965 — 344
2. Oregon Milk Network, October–December and Annual Summary 1965 — 345
3. Washington Milk Network, October–December and Annual Summaries, 1964 and 1965 — 347

115

**CONTENTS—continued**

Page

Food and Diet Surveillance Activities 349

(including list of programs previously reported)

1. Strontium-90 in Tri-City Diets, August–October 1965 349
2. Estimated Daily Intake of Radionuclides in California Diets, May–August 1965 351

SECTION II. WATER 353

(including list of programs previously reported)

Gross Radioactivity, December 1965, and Strontium-90, April–September 1965, in Surface Waters of the United States, *FWPCA* 354

Radioactivity in New York Surface Water, June–December 1965 359

Radiostrontium in Tap Water, May and July–November 1965, *AEC* 361

SECTION III. AIR AND DEPOSITION 363

Radioactivity in Airborne Particulates and Precipitation

(including list of programs previously reported) 364

1. Radiation Surveillance Network, February 1966, *PHS* 364
2. Canadian Air and Precipitation Monitoring Program, February 1966 367
3. Pan American Air Sampling Program, February 1966, *PAHO* and *PHS* 368

SECTION IV. OTHER DATA 370

Strontium-90 in Human Bone, First Quarter 1965, *PHS* 370

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 372

1. Brookhaven National Laboratory, July–December 1965 373
2. Rocky Flats Plant, July–December 1965 374

SECTION V. TECHNICAL NOTES 376

Reported Nuclear Detonations, May 1966 376

Synopses iii

Symbols, Units, and Equivalents Inside back cover

**RADIOLOGICAL HEALTH DATA AND REPORTS**

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116

# COLORADO DENTAL X-RAY MACHINE SURVEY, 1961–APRIL 1965

*R. W. Alcox,*[1] *R. A. Downs,*[2] *and P. W. Jacoe*[2]

**SYNOPSIS — Results of a two-phase program for examining dental X-ray machines showed marked progress by the dental profession in correcting equipment and procedural deficiencies identified by mail-order surveys and physical surveys conducted by the Colorado State Department of Public Health. The first phase of the program was a "Surpak" mail-order survey and the second phase was a physical survey using standards recommended by the U.S. Public Health Service for X-ray beam diameters, filtration of the primary beam, beam definition, and leakage. Following the first phase of the study, the number of machines having beam diameters of 2.75 inches or less increased from 48 to 73 percent; following modifications during the physical survey phase, 85 percent of the machines met the standards. Improvement in meeting filtration standards is shown in a rise from 25 percent compliance during the first survey to 74 percent. During the physical surveys, many areas of dental radiographic practice were examined and specific changes were made or recommended to minimize exposure to both patients and dental personnel. The most common procedural errors observed were overexposure and inadequate development of film.**

As a part of the overall program to assure the safe and effective use of X-ray machines in Colorado, the Colorado State Department of Public Health, in cooperation with the Colorado Dental Association and with local health departments, has conducted a two-phase program to identify and correct possible public health hazards arising from the improper use of dental X-rays in the State. This report presents the findings of the program for the period 1961–April 1965.

The initial phase of the dental radiological health program was a mail-order survey for identifying several of the most important factors that contribute to unnecessary radiation exposure from dental X-ray equipment. For this purpose dentists were supplied with a specially prepared film kit known as the Surpak (*1*). This kind of survey can be made with a minimium of highly trained personnel.

The second phase and a continuing activity of the State dental radiological health program consists of mandatory registration and voluntary physical survey inspection of the dental X-ray equipment used in the State. Thus far, 643 X-ray units have been inspected by the Surpak method and 764 units have been inspected by the physical survey method. Physical surveys are comprehensive and exhaustive inspections requiring the services of trained radiation personnel, equipped with suitable instruments to measure the radiation output of the equipment and demonstrate scatter radiation to the practitioner. The physical survey involves the investigation of the many facets of dental radiographic practice that may contribute unnecessary radiation exposure to both dental personnel and their patients. During the survey an opportunity is provided to install corrective devices "on the spot" for many practitioners. The surveyor, by measuring radiation levels in various locations, can also assist in selecting a location so as to minimize exposure to the dentist and his personnel during X-ray procedures.

---

[1] Dr. Alcox is chief, Dental X-ray Program, State Assistance Branch, Division of Radiological Health, U.S. Public Health Service, Rockville, Maryland.

[2] Dr. Downs is director, Division of Special Health Services; Mr. Jacoe is chief, Radiological Health Section of the Division of Occupational and Radiological Health, Colorado State Department of Public Health, Denver, Colorado.

### *Beam diameter and filtration standards*

The State of Colorado has adopted the beam diameter and filtration standards recommended by the U.S. Public Health Service (*2*). These standards require that beam diameters should be 2.75 inches at the tip of the cone and shall not exceed 3.0 inches. The recommended amount of filtration is 2 mm total aluminum equivalent for equipment operating below 70 kVp and 2.5 mm above 70 kVp. The other recommendations adopted by the State Health Department are based on those of the Radiation Protection Committee of the American Academy of Oral Roentgenology (*3*), and the National Council on Radiation Protection and Measurements (*4*).

The purpose in collimating or restricting the diameter of the X-ray beam to 2.75 inches at the tip of the pointer cone is to limit the exposure to the area of diagnostic concern. Large beams needlessly irradiate structures such as the lens of the eye, the thyroid gland, and contiguous structures in the neck and head, while contributing nothing of diagnostic value to the radiograph. Radiation of the lens of the eye and the thyroid gland may be a contributing factor to cataractogenesis and thyroid tumorigenesis(*5*). Collimation of the primary beam to the area of diagnostic concern also leads to better defined radiographs by diminishing backscatter radiation.

Filtration of the primary X-ray beam reduces the low energy portion of the X-ray beam ("soft X-rays") which do not have sufficient penetrating ability to reach the film. These portions of the X-ray beam would otherwise be absorbed by the patient and contribute nothing to the radiograph. Total filtration is composed of "inherent" and "added" filtration. Inherent filtration is that filtration already present due to the structural elements of the tube head; added filtration is that additional filter material (usually aluminum) which brings the total filtration up to the recommended values.

### *Initial survey*

In 1961, the use of the dental Surpak was introduced into the State through the cooperative efforts of the Colorado Dental Association, the Colorado State Department of Public Health, local health agencies, and the Public Health Service. Specially prepared 8- by 10-inch X-ray film packs (Surpaks) were mailed to participating dentists. The films were exposed according to directions printed on the outside of the Surpak and were mailed to the Colorado State Department of Public Health. Accumulated Surpak films were shipped periodically to the Public Health Service Radiological Health Laboratory in Rockville, Maryland, for processing and analysis of data. The Surpak provided information on filtration, beam diameter, beam symmetry, beam definition, and leakage in the anterior direction. This information was returned to the State or local health department, which in turn informed the dentist as to whether or not his equipment met the recommended standards. If the equipment did not meet the recommended standards, the dentist was so advised and urged to make the necessary modifications of his equipment.

### *Physical survey program*

The Colorado Department of Public Health began a program in 1963 to register the X-ray machines throughout the State. Since that time, the State or local health departments have offered the services of radiological health specialists to survey registered machines. Where a local health department exists, its personnel assist in the survey of X-ray equipment installations. In other areas of the State, the surveys are performed directly by State Health Department personnel. All survey data are treated as confidential information; individuals are not identified in statistical analyses or reports.

Health department personnel gather and record information on each machine's characteristics and discuss findings on the spot with

118

the machine operator. When possible, collimators and filters are provided as a service. Where indicated on the basis of survey findings, suggestions are offered to the operating personnel to enable them to reduce unnecessary radiation exposure to their patients and themselves. Followup letters to the dentist summarize findings and repeat suggestions.

The data obtained are sent to the PHS Radiological Health Laboratory, which provides compilation, processing, and analytical services to the State Health Department.

### *Physical survey procedures*

During the physical inspection, health department personnel check each machine for filtration by noting (1) the added filtration and the inherent filtration listed by the manufacturer; (2) the beam diameter, with a fluorescent screen; (3) the roentgen output, using a Victoreen r-meter both before and after filtration has been added; and (4) other important factors including cord length, timer control, pointer cone, and tube head stability. A number of operational questions are asked, including the number of films taken per week, average exposure time, use of protective barriers and leaded aprons, personnel monitoring, type of film used, development time, development temperature, and interval between development solution changes. The third area of inspection is the operating position of the dentist and/or assistant. Rice bags, 5 inches in diameter and 8 inches tall, are used as a phantom to scatter the radiation in a manner similar to a patient's head. Measurements with a "Cutie Pie" survey meter are taken where the X-ray personnel stand for right and left bitewing exposures and the upper anterior periapical exposure. Based on these measurements, positions affording the lowest exposure rate to operating personnel are selected and recommended to the operators.

### *Beam diameter*

The Surpak survey showed only 48 percent of the machines tested had a beam diameter of 2.75 inches or less. During the subsequent physical survey, it was found that 73 percent of the machines tested had beam diameters of 2.75 inches or less, indicating that the Surpak survey had stimulated corrective action. After the physical survey, 85 percent of the machines had beam diameters of 2.75 inches or less, even though some machines could not be corrected because either the pointer cone could not be removed or a special size collimator was needed.

### *Filtration*

The Public Health Service recommendations (2) for filtration are used in the survey. Where the total filtration was less than the accepted recommendations, additional filtration was supplied by the survey team. Figure 1 shows the amount of total filtration before and after modification. Substantial improvement in filtration can be noted by comparing the "before" and "after" portions of the graph. Some machines which needed additional filtration could not be corrected because either the pointer cone could not be removed or a special size filter was needed.

The exposure rate at the end of the pointer cone was 1 roentgen per second or less in 49 percent of machines before modifications and in 71 percent of machines after modifications, indicating a reduction in exposure rate due to the filtration added during the survey.

### *Other physical characteristics*

The findings of the physical survey, with respect to the type of timer used, showed that slightly more than half of the dental X-ray units have a mechanical timer, while the remainder use electronic timers. The survey also showed that 86 percent of the units had control cables which permitted the operator to stand at least 6 feet from the tube head, and that 95 percent of the X-ray machines inspected had adequate tube head stability.

Table 1 shows the percentage distribution of pointer cone types in use. Comparison with national figures indicates that the use of a long open cone is reported by a greater percentage of

**Table 1. Distribution of pointer cone types in use**

| Type of cone | Percent |
|---|---|
| Short pointed | 69.0 |
| Short open | 5.4 |
| Long pointed | 11.3 |
| Long open | 12.8 |
| None | 0.4 |
| Not stated | 1.0 |

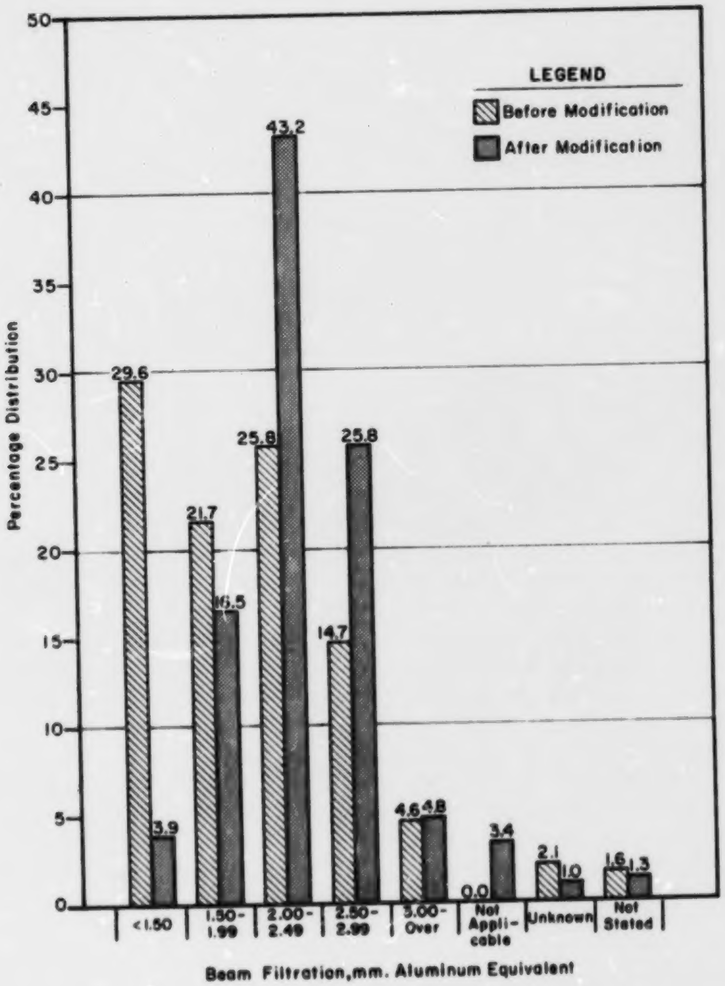

Figure 1. Percentage distribution by beam filtration, before and after modification

dentists in Colorado than in the rest of the United States. The use of an open cone is recommended, since the least amount of scatter radiation results from this type of cone.

Leakage radiation was detected in only 2.9 percent of the X-ray units inspected.

*Film speed used*

Table 2 shows the speed groups of X-ray film used. Each film speed is designated by the reciprocal of the exposure in roentgens required to produce a density of 1.0 under set conditions (*6*). Thus, low speed films have low numbers and the fast speed films have high numbers. The decrease in radiation exposure, when going from group "B" to group "D", can be up to eightfold. Therefore, it is evident that the use

Table 2. Type of film used

| Speed group | Speed range in reciprocal roentgens | Percent distribution |
|---|---|---|
| B | 3.0— 6.0 | 18.5 |
| C | 6.0—12.0 | 18.5 |
| D | 12.0—24.0 | 53.1 |
| Not stated | Not stated | 9.9 |

of the high-speed films permits specific reductions in unnecessary exposure to patients and personnel.

*Exposure and development procedures*

In many instances, the exposure and development procedures were faulty. The most common procedural errors were long exposure time and a short development time. Such practices of overexposure and underdevelopment of film increases the unnecessary radiation exposure to both patients and personnel.

The percentage distribution of development time by film speed is shown in figure 2. The greatest percentage of dentists develops film for 2.5 to 3 minutes, rather than a more optimal 5 minutes. Many dentists estimated the reported developing time using the "sight" method instead of a timer. This involves checking the film by sight against a safelight during development until a suitable radiograph is obtained. This practice often leads to overexposing and underdeveloping.

The development temperature was reported to be 68° to 70°F. by 73 percent of the participants. This is an optimal temperature. Fifty-one percent of the dentists reported that they changed their developing solutions every 4 weeks. The next most common intervals were 8, 2, and 6 weeks (11, 10, and 9 percent, respectively). The developing solutions should be changed at least every 4 weeks as they deteriorate more from oxidation and exposure to air than they do from the workload encountered in the average dental office.

*Exposure to patients and personnel*

The reduction of radiation exposure to the operating personnel as well as the patients was of primary importance during the survey. To obtain exposure figures on operating personnel, readings were taken at normal operating positions, and at other possible operating positions, until the position of minimal exposure was found. In addition, the presence of protective

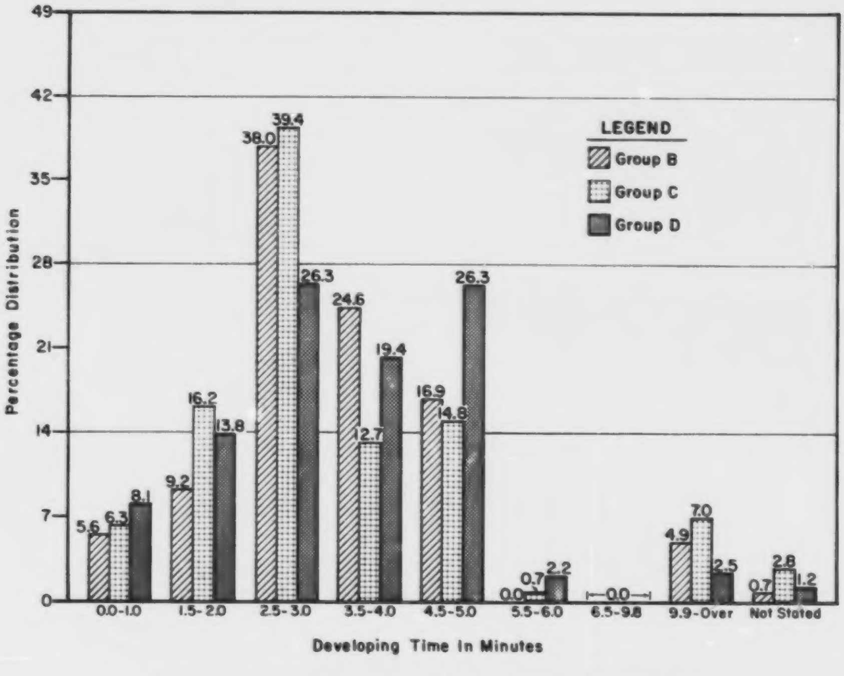

**Figure 2. Percentage distribution by developing time for film speeds**

**Table 3. Percentage distribution of dentists' occupational exposure in mR per hour for old and new positions**

| Occupational exposure | Left bitewing exposure | | Anterior periapical exposure | | Right bitewing exposure | |
|---|---|---|---|---|---|---|
| | Old position | New position | Old position | New position | Old position | New position |
| 0–19 | 25.3 | 56.9 | 24.6 | 58.0 | 26.8 | 57.1 |
| 20–49 | 12.6 | 4.4 | 10.2 | 4.0 | 10.8 | 4.7 |
| 50–99 | 12.1 | 2.0 | 12.8 | 3.4 | 16.5 | 2.0 |
| 100–999 | 36.1 | 2.7 | 40.0 | 2.5 | 33.6 | 2.3 |
| 1,000–3,499 | 2.9 | 0.0 | 2.7 | 0.0 | 2.2 | 0.0 |
| 3,500–5,999 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Not applicable [a] | 0.1 | 1.4 | 0.0 | 1.6 | 0.1 | 2.3 |
| Unknown or not stated | 10.6 | 32.6 | 9.7 | 30.5 | 10.0 | 31.6 |

[a] Dentists' technique and operating procedures are such that no modifications are necessary.

**Table 4. Percentage distribution of assistants' occupational exposure in mR per hour for old and new positions**

| Occupational exposure | Left bitewing exposure | | Anterior periapical exposure | | Right bitewing exposure | |
|---|---|---|---|---|---|---|
| | Old position | New position | Old position | New position | Old position | New position |
| 0–19 | 31.8 | 41.3 | 32.3 | 42.4 | 33.6 | 41.5 |
| 20–49 | 9.7 | 3.3 | 9.0 | 2.3 | 7.7 | 4.2 |
| 50–99 | 7.6 | 0.9 | 9.5 | 1.6 | 8.3 | 1.0 |
| 100–999 | 17.7 | 1.6 | 16.7 | 0.9 | 17.2 | 0.9 |
| 1,000–3,499 | 1.6 | 0.0 | 1.2 | 0.0 | 1.1 | 0.0 |
| 3,500–5,999 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Not applicable [a] | 9.0 | 11.6 | 8.9 | 11.6 | 9.0 | 12.0 |
| Not stated | 22.5 | 41.3 | 22.4 | 41.2 | 23.1 | 40.4 |

[a] Dentists' technique and operating procedures are such that no modifications are necessary.

barriers, the use of leaded aprons for the patient and operator, the type of personnel monitoring, and the number of films per week were noted.

Tables 3 and 4 show the exposure in mR/hr to dentists and assistants at old positions and at new recommended positions. These tables show the great reduction of occupational exposure that can be achieved by utilizing the positions identified by the surveyors in their inspections.

A protective barrier of some sort was used by 64 percent of the operators reporting. This indicates an awareness of the value of shielding. Interestingly, 76 percent of the dentists did not use leaded aprons in any way.

The majority (78 percent) of dentists reported that they were using no type of personnel monitoring. Six percent indicated the use of a commercial film badge service. Thirteen percent indicated the use of dental film with a coin or paper clip attached; this is of questionable value because of the lack of quantitative information.

The percentage distribution of the number of films exposed per week (figure 3) reveals that the dentists in Colorado expose approximately the same number of films per week as the rest of the national average. Fifty-nine percent of the offices surveyed exposed 50 or fewer films per week; 75 percent exposed 75 or fewer films per week; and 85 percent exposed fewer than 100 films per week.

### *Results*

Selected results of the Surpak and physical surveys are summarized in table 5. It is interesting to note that in many cases the beam diameters and filtration were corrected between the time of the Surpak survey and the physical survey. Obviously, the Surpak survey phase pointed out machines needing correction. The dental profession in Colorado is to be congratulated on its promptness in making indicated corrections. The findings of this study clearly demonstrate the value of the Surpak survey. The effectiveness of the physical survey phase is shown in the last two columns of the table.

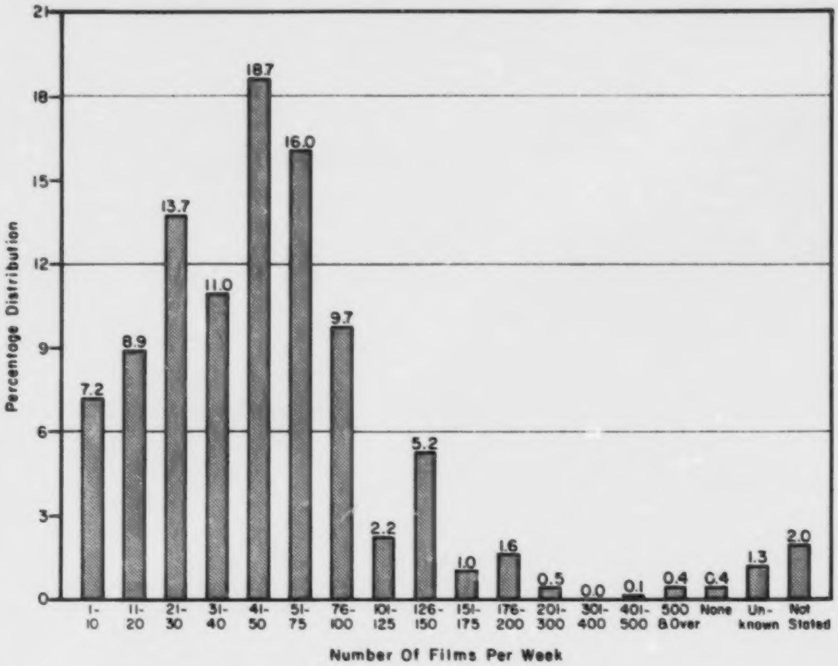

Figure 3. Percentage distribution by number of films per week

Table 5. Results of Surpak and physical surveys

| Findings | Surpak survey (percent) | Physical survey | |
|---|---|---|---|
| | | Percent before modification | Percent after modification |
| Beam diameter 2.75 inches or less | 48 | 73 | 85 |
| Beam diameter 3.0 inches or less | 69 | 78 | 90 |
| Filtration ≥2 mm aluminum equivalent | 25 | 46 | 74 |
| Long pointer cone | 22 | 24 | 24 |
| Good beam symmetry | 95 | | |
| No anterior leakage | 97 | | |
| Acceptable beam definition [a] | 90 | | |

[a] Beam definition is considered acceptable when the Surpak film exhibits a well-defined exposure area with little or no scattered radiation.

Corrections made as a result of this survey resulted in a reduction in potential patient and operator exposure.

Comparison with national figures for collimation and filtration indicates that data for X-ray machines in Colorado were nearly the same as those for X-ray machines in the United States as a whole (*7*).

## *Acknowledgements*

The cooperation of the Colorado dental profession in making these surveys possible is gratefully acknowledged.

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# RADIOACTIVITY IN MILK IN THE UNITED KINGDOM, 1962-1965

*R. S. Bruce* [1]

SYNOPSIS—Radiochemical analyses of raw milk produced in the United Kingdom showed that in 1962 the total iodine-131 in milk was about 85 percent of that found in the autumn of 1961; subsequently, levels have remained below the limit of detection. Concentrations of strontium-90 and cesium-137 increased sharply in 1962 and again in 1963, reaching maximum levels in the middle of the year. Since then, apart from seasonal fluctuations, there has been a general decrease in contamination. The annual average ratio of strontium-90 to calcium in milk in the United Kingdom increased from 5.9 pCi/g in 1961 to 28 pCi/g in 1964, and fell to 19 pCi/g in 1965. The mean concentration of cesium-137 changed similarly, the values for 1964 and 1965 being, respectively, 153 and 98 pCi/liter.

Since 1958, the Agricultural Research Council Radiobiological Laboratory has performed radiochemical analyses of raw milk produced in the United Kingdom. For the "countrywide" survey, until the end of 1964, raw milk was collected from over 200 depots which together handled about 40 percent of the country's production. Figure 1 shows the sources of the milk samples and the boundaries of the zones. The principles on which the depots were selected have already been described (*1*). In 1965, the plan of the survey was revised (*2*) and the number of depots reduced to 82, which handled 28 percent of the total production in the United Kingdom. The number of zones in England was also reduced from 7 to 4 by combining three pairs of adjacent zones. Samples, representative of the total milk received from farms, are collected on 2 days in each month from each group of depots and bulked in proportion to the quantity of milk they handle.

### *Iodine–131*

When atmospheric nuclear testing was resumed in September 1961, arrangements were made for the routine analysis of iodine–131 in milk. In the last quarter of both 1961 and 1962, milk from the countrywide survey was analyzed at weekly intervals. In addition to the countrywide survey, samples were obtained daily from up to 23 "regular sampling points" to enable day-to-day variations to be followed more closely. Full details of the sampling programs are given in the laboratory's reports (*3,4*).

Results to the end of April 1962 have already been given (*5*); further results from the countrywide survey to the end of December 1962 are given in table 1 and trends in the concentration of iodine-131 in milk since the survey began are shown in figure 2.

From May to mid-August, very low levels of iodine–131 appeared sporadically in different parts of the country. These were never maintained for more than a few days and no iodine-131 was detected in the bulked samples from

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[1] Agricultural Research Council Radiobiological Laboratory, England

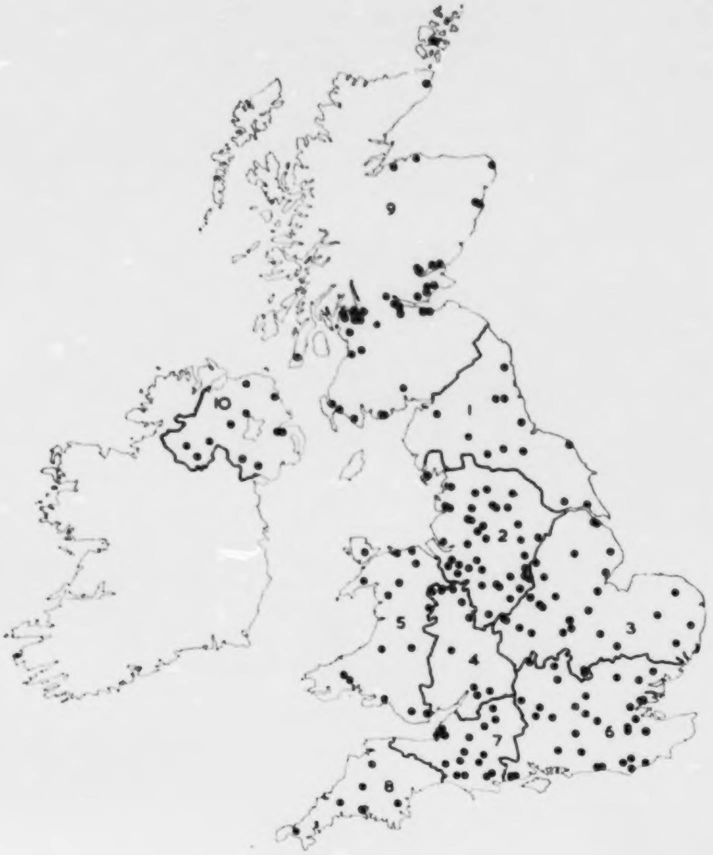

**Figure 1. Map showing sources of samples and boundaries of zones in the countrywide survey of milk**

*Zones: 1 Northern England*
*2 North West England*
*3 East and East Midlands*
*4 West Midlands*
*5 Wales*
*6 South and South East England*
*7 Mid-Western England*
*8 Far Western England*
*9 Scotland*
*10 Northern Ireland*

the countrywide survey. In late August these low levels occurred more frequently and in the first week of September a marked rise occurred. There was some decrease toward the end of September but another peak occurred at the beginning of October. During these 2 months, the weekly average values for iodine-131 in milk from the regular sampling points ranged from 20 to 87 pCi/liter and the countrywide average value from 24 to 96 pCi/liter. The iodine-131 which entered milk in this period was about two-thirds of that found at the corresponding time in 1961 during earlier weapons tests in high northern latitudes. In the last week of October the levels fell to only about twice the limit of accurate detection (11 pCi/liter), but this decrease was followed by a pronounced rise in mid-November when the weekly average values for the regular sampling points and for the countrywide survey were 143 and 176 pCi/liter, respectively. These levels were comparable with the highest found in the autumn of 1961, although similar levels were then maintained over a longer period. In some of the individual zones the increase was more marked and in Scotland the weekly bulk sample representative of production on November 12 contained 370 pCi/liter. This rapid increase in

**Table 1. Iodine-131 concentrations in United Kingdom milk: results of countrywide survey, September to December 1962**

| Date of sampling (1962) | Iodine-131, pCi/liter | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Zone | | | | | | | | | | Country-wide mean weighted for production |
| | Northern England | North West England | East and East Midlands | South and South East England | West Midlands | Mid-Western England | Far Western England | Wales | Scotland | Northern Ireland | |
| Sept 1 | — | — | — | — | — | — | — | — | — | — | 25 |
| 15 | 114 | 45 | 50 | 51 | 44 | 47 | 74 | 94 | 87 | 78 | 65 |
| 24 | 71 | 30 | 43 | 32 | 29 | 41 | 30 | 43 | 66 | 43 | 42 |
| Oct 1 | 88 | 141 | 62 | 75 | 84 | 89 | 95 | 86 | 103 | 105 | 96 |
| 8 | 98 | 76 | 69 | 41 | 71 | 67 | 76 | 83 | 111 | 52 | 75 |
| 15 | 37 | 44 | 34 | 25 | 37 | 24 | 43 | 41 | 53 | 37 | 38 |
| 22 | 46 | 37 | 14 | <11 | 14 | 13 | 23 | 24 | 30 | 37 | 24 |
| 29 | 66 | 30 | 33 | 36 | 33 | 60 | 65 | 53 | 61 | 60 | 47 |
| Nov 5 | 52 | 28 | 15 | 44 | 39 | 60 | 53 | 48 | 47 | 22 | 41 |
| 12 | 248 | 140 | 158 | 78 | 146 | 138 | 153 | 186 | 370 | 204 | 176 |
| 19 | 82 | 89 | 105 | 85 | 87 | 149 | 157 | 149 | 125 | 172 | 115 |
| 26 | 46 | 46 | 57 | 61 | 57 | 72 | 178 | 67 | 44 | 86 | 66 |
| Dec 3 | 27 | 29 | 58 | 43 | 30 | 70 | 62 | 66 | 30 | 136 | 50 |
| 10 | <11 | 19 | <11 | <11 | 19 | 12 | 27 | 22 | 36 | 52 | 19 |
| 17 | <11 | <11 | 33 | 19 | 12 | 17 | 28 | 31 | 23 | 40 | 19 |
| 24 | <11 | <11 | 24 | <11 | 28 | <11 | 27 | 16 | <11 | <11 | <11 |
| 31 | 27 | <11 | <11 | <11 | 18 | <11 | <11 | 31 | <11 | 15 | <11 |

levels was followed by a rapid decline and by early December the average level was about 50 pCi/liter. Later in that month the severe weather, which covered pastures in many parts of the country with snow, hastened the decrease. Since January 1963 the concentrations of iodine–131 in milk have remained below the limit of detection.

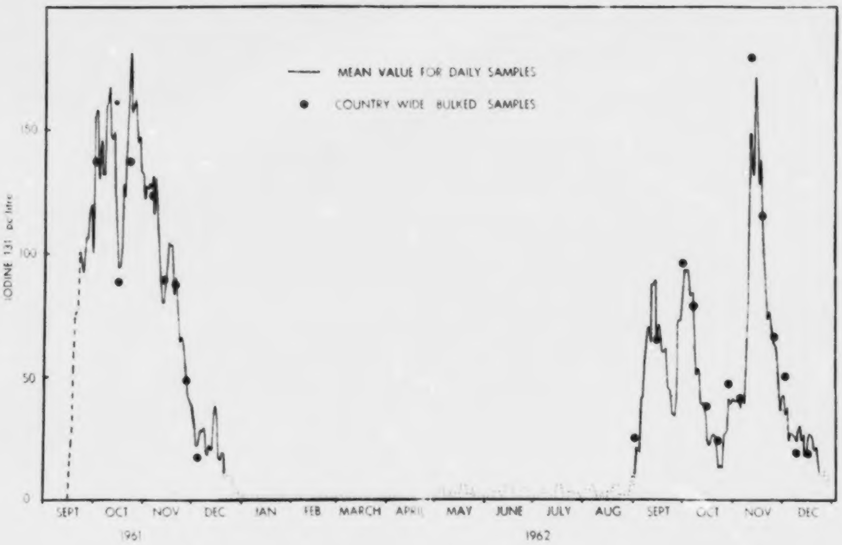

**Figure 2. Iodine–131 in milk: Average daily values for regular sampling points, September 1961 to December 1962. The country-wide mean values are also shown.**

Values for early September 1961 are shown by a broken line, as sampling was then limited. A dotted line is used when values were below the limit of accurate detection (11 pCi/liter)

### *Strontium-90*

From 1962 to 1965 samples of milk from the individual zones of the countrywide survey were bulked and analyzed for strontium-90 at either 6-week or quarterly intervals.

Results for 1961 were reported earlier (*5*) and detailed results for subsequent years appear in the Laboratory's reports (*2,4,6*). Annual mean results, expressed as ratios of strontium-90 to calcium, for the individual zones of the countrywide survey from 1962 to 1965, are given in table 2. Trends for the countrywide mean ratio from 1958 to 1965 are shown in figure 3; the estimated average deposition of strontium-90 in the United Kingdom is also shown for comparison.

The concentrations of strontium-90 in milk rose sharply in the late spring of 1962, reaching a maximum in August and then decreasing to rather lower levels later in the year. In 1963 the substantial increase in the rate of fallout due to the combined effects of the nuclear tests in 1961 and 1962 caused the countrywide average ratio of strontium-90 to calcium to increase by a factor of 3.5 between March and August when the contamination of milk reached the highest levels since the survey began. Since then, apart from seasonal fluctuations, there has been a steady decline in the concentrations of strontium-90; and at the end of 1965 they were lower than at any time since early in 1963.

**Table 2. Countrywide survey in milk in the United Kingdom: annual mean ratios of strontium-90 to calcium 1962–1965**

| Zone | Mean ratio: $^{90}$Sr/Ca, pCi/g | | | |
|---|---|---|---|---|
| | 1962 | 1963 | 1964 | 1965 |
| Northern England | 11.6 | 25.8 | 30.7 | 18.1 |
| North West England | 9.5 | 20.5 | 22.0 | |
| East and East Midlands | 7.2 | 15.8 | 16.6 | 13.0 |
| South and South East England | 8.0 | 20.2 | 21.1 | |
| West Midlands | 10.0 | 19.3 | 20.2 | 14.6 |
| Mid-Western England | 9.5 | 22.4 | 27.8 | |
| Far Western England | 17.5 | 39.5 | 36.6 | 24.3 |
| Wales | 16.3 | 35.4 | 41.7 | 26.5 |
| Scotland | 16.8 | 33.4 | 36.7 | 26.3 |
| Northern Ireland | 16.4 | 38.1 | 39.2 | 26.8 |
| Countrywide mean weighted for production | 11.7 | 25.6 | 28.0 | 19.0 |

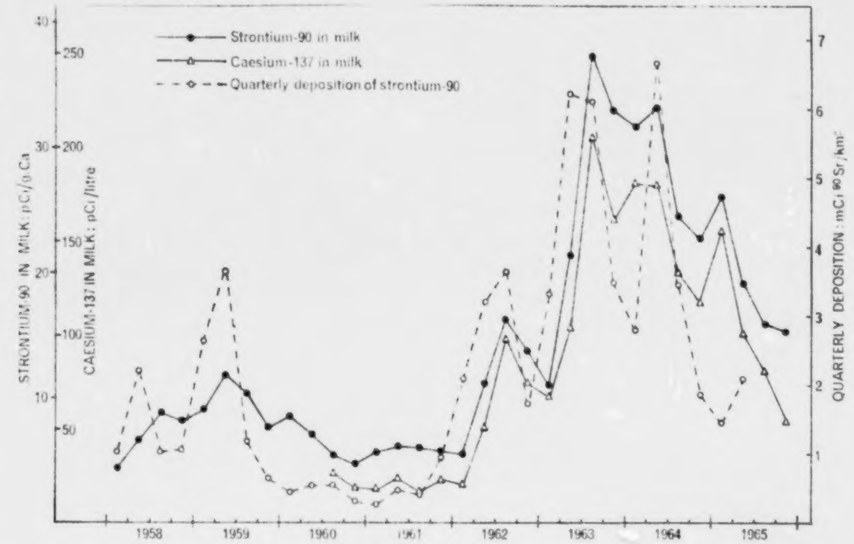

**Figure 3. The countrywide average ratio of strontium-90 to calcium and the concentration of cesium-137 in milk compared with the estimated quarterly rate of fallout**

The rate of fallout is shown by the deposition of strontium-90; as the ratio of cesium-137 to strontium-90 in fallout is relatively constant, the trends for strontium-90 indicate those for cesium-137 also. The deposition of strontium-90 is calculated from the mean concentration in rain, measured quarterly at seven sites by the Atomic Energy Authority, and the average rainfall in the United Kingdom

The annual countrywide mean ratio of strontium-90 to calcium increased from 5.9 pCi/g in 1961 to 28.0 pCi/g in 1964, and then decreased by about one-third to 19.0 pCi/g in 1965. The countrywide 12-month mean was at its highest for the period July 1963 to June 1964 when the value was 34 pCi/g. In general, the results for individual zones of the survey ranged from about 0.6 to 1.5 times the countrywide average, differences between zones being attributable mainly to regional differences in rainfall.

### *Cesium-137*

From the middle of 1960 until September 1961, cesium-137 concentrations were determined every 3 months in bulked samples of milk. With the resumption of weapons testing in September 1961, cesium-137 analyses were performed on samples from individual zones in the countrywide survey at the same intervals as for strontium-90.

The general trends for the changes in the concentrations of cesium-137 in milk were very similar to those for strontium-90 (figure 3); peak concentrations were reached in July 1963 and since then levels have declined. The annual mean concentrations from 1962 to 1965 are summarized in table 3. Countrywide means for the last 9 months of 1960 and for the whole of 1961 were, respectively, 26 pCi/liter and 21 pCi/liter. The annual mean concentration rose to 153 pCi/liter in 1964 and then decreased by one-third to 98 pCi/liter in 1965; the values for individual zones ranged from about 0.6 to 1.7 times the countrywide mean.

**Table 3. Countrywide survey of milk in the United Kingdom: annual mean concentrations of cesium-137, 1962–1965**

| Zone | Mean concentration of cesium-137, pCi/liter | | | |
|---|---|---|---|---|
| | 1962 | 1963 | 1964 | 1965 |
| Northern England | 67 | 140 | 171 | 98 |
| North West England | 51 | 108 | 130 | |
| East and East Midlands | 36 | 74 | 94 | 68 |
| South and South East England | 42 | 94 | 110 | |
| West Midlands | 42 | 90 | 106 | 74 |
| Mid-Western England | 38 | 93 | 109 | |
| Far Western England | 93 | 206 | 220 | 121 |
| Wales | 97 | 209 | 218 | 132 |
| Scotland | 85 | 199 | 205 | 118 |
| Northern Ireland | 110 | 220 | 263 | 164 |
| Countrywide mean weighted for production | 62 | 135 | 153 | 98 |

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# RADIONUCLIDES IN THE UNITED KINGDOM DIET, 1962-1964

*R. S. Bruce* [1]

SYNOPSIS—In continuing United Kingdom diet studies, a fourfold increase in strontium-90 contamination of the average diet has been observed between 1961 and 1964. The ratio of strontium-90 to calcium in the average mixed diet in 1964 was 25.9 pCi/g (corresponding to an intake of 28.5 pCi/day), which is nearly three times the value in 1959. During 1962 to 1964, the relative contributions of strontium-90 from different types of food remain fairly constant. Cesium-137 levels increased markedly between 1961 and 1963, the estimated daily intake, based on assays of five types of food, rising from about 30 to 170 pCi/day; in 1964 the value was 160 pCi/day. Measurements of strontium-89 and barium-140 during 1962 and 1963 indicated that these nuclides were minor radioactive contaminants of the diet.

Responsibility for the investigation of the contamination of human food with radioactive substances in the United Kingdom was assigned in 1957 to the Agricultural Research Council (ARC). In 1958, when surveys of radioactivity in human diet were begun in the ARC Radiobiological Laboratory, attention was confined to strontium-90 as this is the long-lived component of worldwide fallout which delivers the highest radiation doses to man through the contamination of his food. Some measurements of the shorter-lived isotope, strontium-89, were also made but their primary purpose was to provide information on the mechanisms by which strontium-90 enters the diet. In subsequent years, the sampling network devised for strontium-90 provided a basis for measurements of iodine-131, barium-140, and cesium-137. The general principles of the survey have been described previously (*1*) and full details of sampling procedures and results are given in the Laboratory's reports (*2*).

### *Content of strontium-90 in the average diet*

The mean quantity of strontium-90 in the average mixed diet of the population in the United Kingdom has been calculated by multiplying the mean ratio of strontium-90 to calcium in different types of food by the quantities of calcium they contribute to the diet. This is illustrated by the results for 1964 which are given in table 1. Results for previous years, summarized in table 2, were calculated in a similar manner.

The countrywide survey provides the necessary information on milk, cheese, eggs, and cereals. These components provide over 80 percent of the dietary calcium which is of either animal or vegetable origin. The survey also provides information on the two most widely consumed types of vegetables, potatoes, and leafy brassicas. As plant species do not discriminate appreciably between strontium and calcium, the ratio of strontium-90 to calcium in potatoes has been taken as representative of that in all root vegetables and the ratio in leafy brassicas as representative of that in other vegetables and fruit.

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[1] Agricultural Research Council Radiobiological Laboratory, England.

**Table 1. Mean content of strontium-90 in the diet in the United Kingdom, 1964**

| Origin | Mean daily intake of calcium [a] (mg) | Mean ratio: $^{90}$Sr/Ca (pCi/g) | Estimated daily intake of $^{90}$Sr (pCi) |
|---|---|---|---|
| Dairy produce: | | | |
| Milk and cream | 530 | 28.0 | 14.84 |
| Cheese | 104 | 24.7 | 2.57 |
| Vegetables and fruit: | | | |
| Root vegetables | 25 | 48.4 | 1.21 |
| Leaf and other vegetables | 36 | 30.6 | 1.10 |
| Fruit, etc | 17 | 30.6 | 0.52 |
| Flour and cereals | [b] 248 | 17.4 | 4.32 |
| Other animal produce: | | | |
| Eggs | 21 | 27.6 | 0.58 |
| Meat | 22 | 56.0 | 1.23 |
| Other sources: | | | |
| Drinking water | 60 | — | 1.07 |
| Tea | — | — | 1.10 |
| Miscellaneous | 39 | — | — |
| Total mixed diet | 1,102 | 25.9 | 28.54 |

[a] Values computed by the Ministry of Agriculture, Fisheries and Food from surveys of domestic food consumption. The values differ slightly from those used to calculate the daily intake in previous years.

[b] This includes about 206 mg mineral calcium added to flour as *creta praeparata*.

The small contribution of meat to the total intake of strontium-90 has been estimated from the results of the countrywide survey of milk on the basis that the ratio of strontium-90 to calcium in meat is about twice that in milk from the same animals; this assumption over-estimates the contribution of meat because about one-third of the total meat supplies in the United Kingdom are imported from the Southern Hemisphere. While these calculated values are adequate to assess the small contributions of meat to the total intake of strontium-90 in any year, they are not suitable for comparison of changes from year to year or of the situation in different countries. The values for drinking water are provided by measurements on water supplies in different parts of the country (*3*). The contribution from tea has been calculated from the measured strontium-90 content of dry tea on the assumption that the average quantity used per head of population is 11 grams per day and that 10 percent of the strontium-90 present in the dry tea is transferred to the tea infusion.

Table 2 shows that there was a fourfold increase in the contamination of the average diet between 1961 and 1964 and that the ratio of strontium-90 to calcium in 1964 (25.9 pCi/g) was almost three times the value for 1959. The total deposit of strontium-90 in fallout during 1964 was appreciably lower than that during 1963; the fact that there was not a comparable reduction in the contamination of diet reflects the delay in the transfer of radioactivity into foodstuffs due to agricultural factors and also,

**Table 2. Comparison of levels of strontium-90 in the United Kingdom diet, 1958–1964**

| Food item | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 |
|---|---|---|---|---|---|---|---|
| | Mean ratio: $^{90}$Sr/Ca, pCi/g | | | | | | |
| Total diet (including drinking water and tea) [a] | 5.9 | 9.0 | 6.4 | 6.2 | 9.9 | 22.8 | 25.9 |
| Milk and cream | 7.0 | 9.8 | 6.4 | 5.9 | 11.7 | 25.6 | 28.0 |
| Cheese | 7.7 | 7.5 | 5.3 | 4.8 | 8.7 | 19.7 | 24.7 |
| Root vegetables | 14.2 | 23.2 | 19.6 | 24.3 | 25.1 | 53.1 | 48.4 |
| Leaf vegetables and fruit | 8.7 | 14.3 | 8.5 | 10.3 | 17.6 | 35.4 | 30.6 |
| Flour and cereals | 15.9 | 28.0 | 22.7 | 21.8 | 18.4 | 71.9 | [b] 17.4 |
| Eggs | ...... | 9.0 | 6.3 | ...... | 6.2 | 12.0 | 27.6 |
| | Intake of strontium-90, pCi/day | | | | | | |
| Total diet | 6.4 | 9.8 | 6.9 | 6.7 | 10.7 | 24.7 | 28.5 |
| | Percentage of total [c] | | | | | | |
| Milk and cream | 54.3 | 49.7 | 45.7 | 43.7 | 54.2 | 51.4 | 52.0 |
| Cheese | 11.4 | 7.3 | 7.2 | 6.9 | 7.7 | 7.6 | 9.0 |
| Root vegetables | 5.5 | 5.9 | 7.1 | 9.1 | 5.9 | 5.4 | 4.2 |
| Leaf vegetables and fruit | 8.5 | 9.0 | 7.5 | 9.5 | 10.2 | 8.9 | 5.7 |
| Flour and cereals | 11.7 | 13.5 | 15.4 | 15.2 | 8.0 | 13.7 | 15.1 |
| Other foodstuffs | 5.0 | 5.6 | 5.3 | 5.2 | 5.3 | 4.9 | 6.3 |
| Drinking water | 3.6 | 4.4 | 5.2 | 3.7 | 3.8 | 3.4 | 3.7 |
| Tea | ...... | 4.6 | 6.5 | 6.7 | 4.9 | 4.7 | 3.9 |

[a] Account has been taken of mineral calcium (*creta praeparata*) added to flour.

[b] In contrast to previous years, the value for 1964 is based on the analysis of flour to which mineral calcium as *creta praeparata* had been added. The value comparable with those for previous years, when only the natural calcium was present in the samples analyzed, would be about 100 pCi/g.

[c] Tea was not sampled in 1958, so the percentages for this year are not strictly comparable to the others.

130

in some instances, to the delay between production and marketing of foods. This was evident in 1962 when the level of strontium-90 in cereal products, in contrast to other foodstuffs, was less than in 1961 because the grain from which they were manufactured was harvested before the rate of fallout increased late in 1961.

The relative contributions of different types of food to the total intake remained fairly constant. From 1962 to 1964, when the rate of fallout was high, dairy produce accounted for about 60 percent of the total, which is a rather higher proportion than in 1961 when the rate of fallout was low for most of the year. As the ratio of strontium-90 to calcium in dairy produce has not differed markedly from that in the mixed diet, variations in the quantity of milk or cheese consumed would have little effect on the ratio of strontium-90 to calcium in the total diet. Since, however, the ratio in milk varied by a factor of about 2.5 between zones of the countrywide survey (4), it can be caluculated that, depending on the source of milk, the ratio of strontium-90 to calcium in a mixed diet of otherwise average composition would have varied by a factor of about 1.6 between major areas of the country.

The ratio of strontium-90 to calcium in root vegetables is considerably higher than that in the total diet and the same was true to a lesser extent for leaf vegetables and fruit. The small contribution of both these categories of food to the total intake of strontium-90 (each less than 10 percent) causes the contamination of the total diet to be affected little by variations either in the consumption of these foodstuffs or in their origin.

In considering the effect of changes in the quantity of cereal components in diet, the effect of mineral calcium (*creta praeparata*) which is added to all white flour in the United Kingdom must be taken into account. The estimated daily intake from this source is equivalent to about 200 to 250 mg calcium per day and, as can be seen from table 1, the overall ratio of stronium-90 to calcium in cereal foods containing *creta praeparata* is appreciably lower than that in the total diet. Consequently, although an increase in the consumption of cereal products would add to the total intake of strontium-90, it would cause a decrease in the overall ratio in diet. An exception to this situation would occur if an individual ate only wholemeal bread to which no *creta praeparata* had been added (a product which represents only a small fraction of the country's total supplies). The ratio of strontium-90 to calcium in an otherwise normal diet would then be increased by about one-half.

### *Cesium-137 in diet*

Radiation doses to man from cesium-137 are assessed most satisfactorily from whole-body measurements of radioactivity made on living subjects. Measurements of cesium-137 in diet, however, provide useful supplementary information on the effects of differences in dietary habits and on changes in levels which will subsequently be reflected in whole-body measurements on man.

Cesium-137 has been measured in bulked samples of milk, potatoes, leafy brassicas, and flour collected for the investigation of strontium-90. Cesium-137 was also measured in meat; in 1961 and 1962 only home-produced beef and mutton were sampled but, because meat is a major source of cesium-137 in diet, the scale of sampling was increased in 1963 and 1964 to obtain more widely representative samples from both United Kingdom and overseas sources.

Estimates of the approximate content of cesium-137 in the mixed diet from 1961 to 1964 have been made on the basis of the concentrations of cesium-137 in these foodstuffs and the average daily intake of each food (table 3). The concentrations of cesium-137 in potatoes and leafy brassicas have been taken as representative of those in all root vegetables and leaf vegetables, respectively. The contribution from drinking water (0.3 picocuries per day in 1963 and 1964) is negligible compared with that from components of diet.

Table 3 shows that between 1961 and 1963 there was a marked increase in the contamination of diet with cesium-137, the estimated daily intake from the five types of food assayed rising from about 30 to 170 pCi/day. The concentrations of cesium-137 in milk and flour were higher in 1964 than 1963 but the effect of these increases was offset by reduced estimates for meat and vegetables so that the total intakes for the 2 years were comparable.

**Table 3. Estimated mean content of cesium-137 in the mixed diet in the United Kingdom, 1961–1964**

| Diet items | Mean daily intake (liter or kg) | Cesium-137 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Concentration, pCi/liter or kg | | | | Estimated daily intake, pCi | | | |
| | | 1961 | 1962 | 1963 | 1964 | 1961 | 1962 | 1963 | 1964 |
| Milk | 0.43 | 21 | 62 | 135 | 153 | 9 | 26 | 57 | 66 |
| Meat | 0.12 | 98 | 330 | 580 | 490 | 11 | 40 | 70 | 59 |
| Flour (in all forms) | 0.19 | 46 | 30 | 92 | 130 | 9 | 6 | 17 | 25 |
| Root vegetables | 0.24 | 5 | 32 | 73 | 30 | 1.4 | 8 | 19 | 7 |
| Leaf vegetables | 0.11 | 4 | 19 | 40 | 30 | 0.4 | 2 | 4 | 3 |
| Total | — | — | — | — | — | 31 | 82 | 167 | 160 |

The total intake of cesium–137 by individuals is likely to vary from the average much more widely than the ratio of strontium–90 to calcium because it is directly related to the quantity of each food consumed and because changes in the origin of foodstuffs, particularly meat, would have a much more pronounced effect.

### *Strontium–89 and barium–140*

Measurements of the relatively short-lived nuclides, strontium–89 and barium–140, were continued during 1962 and 1963. The results confirmed that these nuclides were only minor sources of exposure to radiation.

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# Data

## Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1,2*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the International Commission on Radiological Protection (*4,5*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature.

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(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

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(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press (1959).

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# NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

| Program | Period reported | Last presented |
|---|---|---|
| Radiostrontium in milk, HASL | April–June 1965 | March 1966 |
| United Kingdom milk | January 1961–April 1962 | October 1962 |

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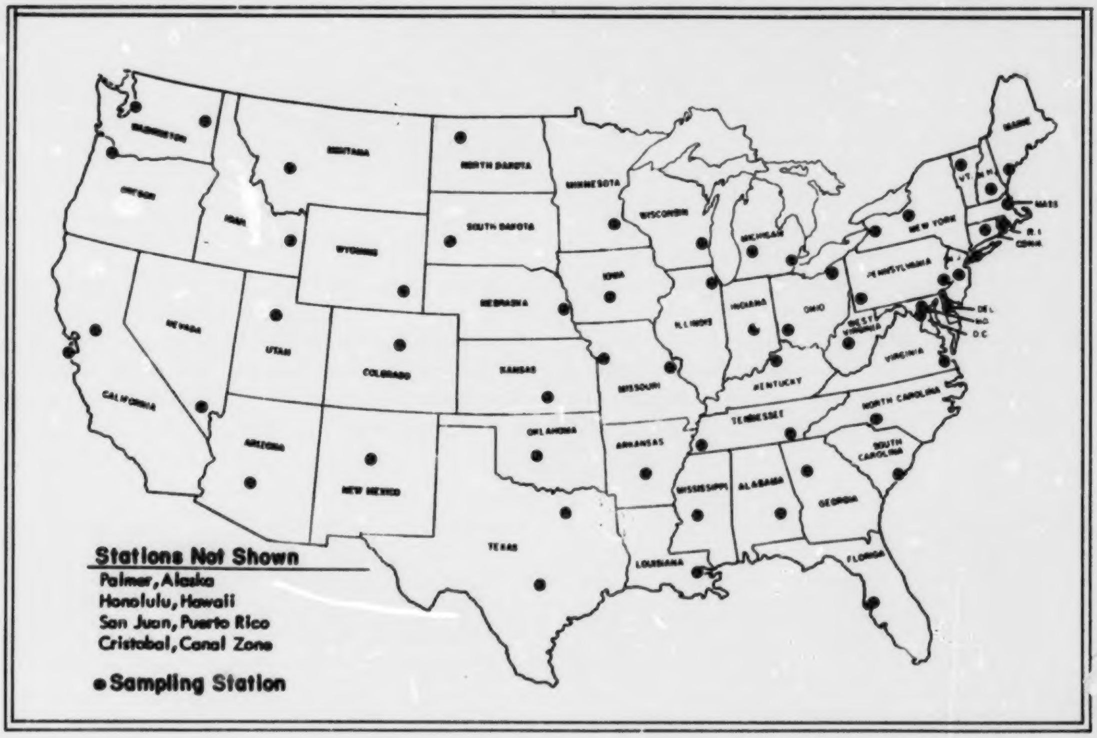
## 1. Pasteurized Milk Network
## February 1966

*Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) was designated to provide nationwide surveillance of radionuclide concentrations in milk through sampling of major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 issue of *Radiological Health Data* (*1*).

The results for February 1966 and the fourth


WASHINGTON
OREGON
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WYOMING
NORTH DAKOTA
SOUTH DAKOTA
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KANSAS
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TEXAS
NEVADA
UTAH
COLORADO
CALIFORNIA
ARIZONA
NEW MEXICO
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
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TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
VT.
N.H.
MAINE
MASS
R.I.
CONN
DEL
MD.
D.C.
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Cristobal, Canal Zone
● Sampling Station

Figure 1. Pasteurized Milk Network sampling locations

**Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the fourth quarter 1965 and February 1966**[a]

| Sampling location | | Calcium, g/liter | | Strontium-89, pCi/liter | | Strontium-90, pCi/liter | | Cesium-137, pCi/liter | |
|---|---|---|---|---|---|---|---|---|---|
| | | Fourth quarter 1965 | February 1966 | Fourth quarter 1965 | February 1966 | Fourth quarter 1965 | February 1966 | Fourth quarter 1965 | February 1966 |
| Ala: | Montgomery | 1.18 | 1.17 | <5 | <5 | 14 | 11 | 30 | 30 |
| Alaska: | Palmer | 1.30 | 1.26 | <5 | <5 | 15 | 15 | 55 | 40 |
| Ariz: | Phoenix | 1.25 | 1.23 | <5 | <5 | 4 | 4 | 15 | 15 |
| Ark: | Little Rock | 1.20 | 1.16 | <5 | <5 | 27 | 23 | 30 | 40 |
| Calif: | Sacramento | 1.27 | 1.27 | <5 | <5 | 4 | 6 | 15 | 10 |
| | San Francisco | 1.29 | 1.22 | <5 | <5 | 4 | 8 | 15 | 20 |
| C.Z: | Cristobal | 1.13 | 1.11 | <5 | <5 | 5 | 3 | 35 | 25 |
| Colo: | Denver | 1.28 | 1.28 | <5 | <5 | 12 | 11 | 25 | 20 |
| Conn: | Hartford | 1.12 | 1.15 | <5 | <5 | 12 | 10 | 40 | 35 |
| Del: | Wilmington | 1.15 | 1.18 | <5 | <5 | 14 | 13 | 35 | 40 |
| D.C: | Washington | 1.16 | 1.14 | <5 | <5 | 13 | 12 | 25 | 30 |
| Fla: | Tampa | 1.18 | 1.18 | <5 | <5 | 14 | 11 | 135 | 110 |
| Ga: | Atlanta | 1.17 | 1.12 | <5 | <5 | 19 | 18 | 45 | 45 |
| Hawaii: | Honolulu | 1.16 | 1.16 | <5 | <5 | 6 | 4 | 40 | 35 |
| Idaho: | Idaho Falls | 1.28 | 1.24 | <5 | <5 | 13 | 13 | 45 | 45 |
| Ill: | Chicago | 1.14 | 1.14 | <5 | <5 | 11 | 11 | 35 | 35 |
| Ind: | Indianapolis | 1.17 | 1.19 | <5 | <5 | 12 | 13 | 25 | 30 |
| Iowa: | Des Moines | 1.26 | 1.26 | <5 | <5 | 14 | 15 | 20 | 25 |
| Kans: | Wichita | 1.27 | 1.26 | <5 | <5 | 13 | 13 | 20 | 15 |
| Ky: | Louisville | 1.16 | 1.17 | <5 | <5 | 17 | 15 | 20 | 25 |
| La: | New Orleans | 1.22 | 1.19 | <5 | <5 | 30 | 28 | 40 | 45 |
| Maine: | Portland | 1.14 | 1.12 | <5 | <5 | 17 | 15 | 65 | 65 |
| Md: | Baltimore | 1.17 | 1.14 | <5 | <5 | 16 | 13 | 25 | 30 |
| Mass: | Boston | 1.15 | 1.16 | <5 | <5 | 16 | 14 | 60 | 60 |
| Mich: | Detroit | 1.12 | 1.13 | <5 | <5 | 11 | 11 | 30 | 35 |
| | Grand Rapids | 1.16 | 1.17 | <5 | <5 | 14 | 15 | 45 | 40 |
| Minn: | Minneapolis | 1.26 | 1.20 | <5 | 5 | 22 | 19 | 40 | 40 |
| Miss: | Jackson | 1.24 | 1.24 | <5 | <5 | 25 | 21 | 25 | 30 |
| Mo: | Kansas City | 1.22 | 1.24 | <5 | <5 | 16 | 15 | 20 | 25 |
| | St. Louis | 1.27 | 1.22 | <5 | <5 | 18 | 16 | 20 | 30 |
| Mont: | Helena | 1.31 | 1.26 | <5 | <5 | 15 | 14 | 45 | 50 |
| Nebr: | Omaha | 1.22 | 1.25 | <5 | <5 | 16 | 16 | 25 | 20 |
| Nev: | Las Vegas | 1.27 | 1.24 | <5 | <5 | 5 | 10 | 25 | 20 |
| N.H: | Manchester | 1.14 | 1.17 | <5 | <5 | 18 | 20 | 70 | 75 |
| N.J: | Trenton | 1.14 | 1.18 | <5 | <5 | 11 | 14 | 30 | 40 |
| N. Mex: | Albuquerque | 1.23 | 1.22 | <5 | <5 | 6 | 4 | 20 | 10 |
| N.Y: | Buffalo | 1.10 | 1.12 | <5 | <5 | 11 | 10 | 40 | 40 |
| | New York | 1.11 | 1.12 | <5 | <5 | 14 | 13 | 40 | 45 |
| | Syracuse | 1.10 | 1.13 | <5 | <5 | 12 | 9 | 35 | 35 |
| N.C: | Charlotte | 1.20 | 1.18 | <5 | <5 | 25 | 20 | 30 | 30 |
| N. Dak: | Minot | 1.27 | 1.23 | <5 | <5 | 30 | 30 | 40 | 45 |
| Ohio: | Cincinnati | 1.15 | 1.16 | <5 | <5 | 13 | 12 | 20 | 25 |
| | Cleveland | 1.14 | 1.17 | <5 | <5 | 13 | 13 | 25 | 35 |
| Okla: | Oklahoma City | 1.17 | 1.16 | <5 | <5 | 14 | 12 | 20 | 25 |
| Ore: | Portland | 1.27 | 1.24 | <5 | <5 | 12 | 11 | 40 | 30 |
| Pa: | Philadelphia | 1.12 | 1.16 | <5 | <5 | 12 | 12 | 30 | 35 |
| | Pittsburgh | 1.13 | 1.17 | <5 | <5 | 17 | 18 | 40 | 45 |
| P.R: | San Juan | 1.11 | 1.09 | <5 | <5 | 9 | 8 | 30 | 30 |
| R.I: | Providence | 1.14 | 1.15 | <5 | <5 | 15 | 10 | 45 | 45 |
| S.C: | Charleston | 1.19 | 1.19 | <5 | <5 | 25 | 23 | 55 | 50 |
| S. Dak: | Rapid City | 1.23 | 1.12 | <5 | <5 | 21 | 18 | 45 | 40 |
| Tenn: | Chattanooga | 1.25 | 1.19 | <5 | <5 | 22 | 22 | 30 | 30 |
| | Memphis | 1.18 | 1.18 | <5 | <5 | 18 | 16 | 20 | 20 |
| Tex: | Austin | 1.17 | 1.15 | <5 | <5 | 6 | 6 | 10 | 15 |
| | Dallas | 1.17 | 1.17 | <5 | <5 | 12 | 13 | 20 | 20 |
| Utah: | Salt Lake City | 1.38 | 1.29 | <5 | <5 | 12 | 14 | 40 | 40 |
| Vt: | Burlington | 1.12 | 1.13 | <5 | <5 | 14 | 15 | 50 | 50 |
| Va: | Norfolk | 1.18 | 1.18 | <5 | <5 | 16 | 15 | 25 | 30 |
| Wash: | Seattle | 1.30 | 1.24 | <5 | <5 | 16 | 16 | 45 | 40 |
| | Spokane | 1.31 | 1.26 | <5 | <5 | 16 | 16 | 45 | 40 |
| W. Va: | Charleston | 1.16 | 1.14 | <5 | <5 | 16 | 14 | 20 | 25 |
| Wis: | Milwaukee | 1.20 | 1.20 | <5 | <5 | 12 | 11 | 40 | 45 |
| Wyo: | Laramie | 1.29 | 1.23 | <5 | <5 | 16 | 17 | 45 | 35 |
| Network average | | 1.20 | 1.19 | <5 | <5 | 14.6 | 13.8 | 35 | 35 |

[a] All iodine-131 and barium-140 values were below detectable levels.

quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

**Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, February and September–December 1965, and January–February 1966.**

| Strontium-90 (pCi/liter) | Number of stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1965 | | | | | 1966 | |
| | Feb | Sept | Oct | Nov | Dec | Jan | Feb |
| Under 10 | 3 | 11 | 8 | 9 | 9 | 10 | 9 |
| 10–19 | 31 | 44 | 46 | 43 | 43 | 46 | 46 |
| 20–29 | 22 | 7 | 7 | 9 | 11 | 6 | 7 |
| 30–39 | 5 | 1 | 2 | 2 | 0 | 1 | 1 |
| 40–49 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, February and September–December 1965, and January–February 1966.**

| Cesium-137 (pCi/liter) | Number of stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1965 | | | | | 1966 | |
| | Feb | Sept | Oct | Nov | Dec | Jan | Feb |
| Under 50 | 8 | 50 | 54 | 57 | 51 | 57 | 56 |
| 50–99 | 38 | 12 | 8 | 5 | 11 | 5 | 6 |
| 100–149 | 15 | 0 | 0 | 1 | 1 | 1 | 1 |
| 150–199 | 2 | 1 | 1 | 0 | 0 | 0 | 0 |

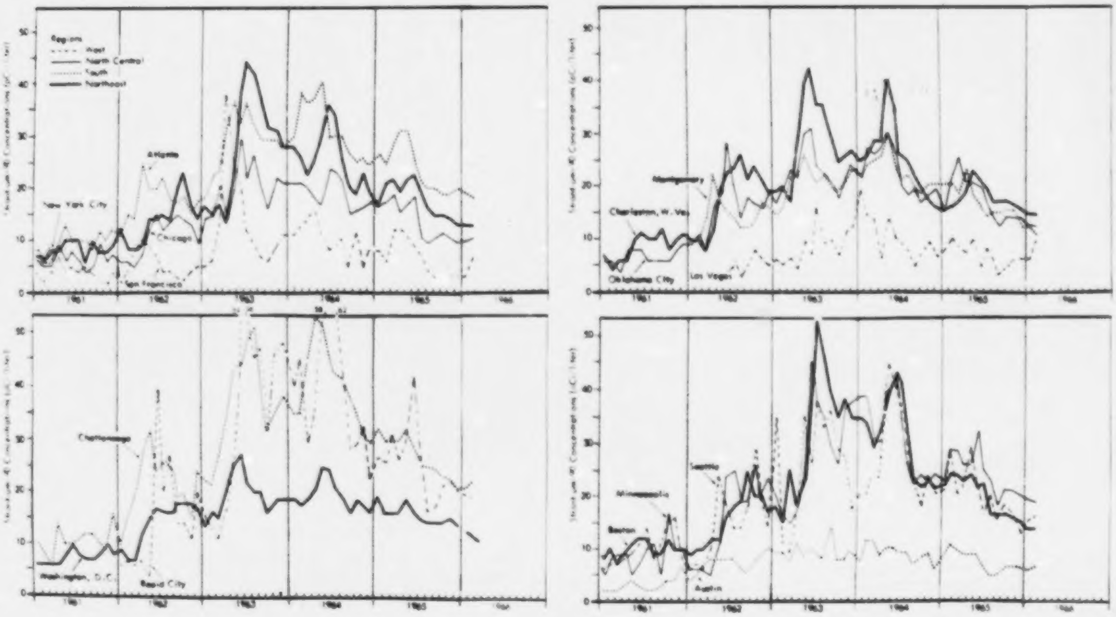

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961–February 1966

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 2 and 3 for February 1965 and for September 1965 through February 1966. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2. During this period the monthly average iodine-131 and barium-140 concentrations in milk were less than 10 pCi/liter.

## 2. Canadian Milk Network
## February 1966[1]

*Radiation Protection Division*
*Department of National Health and Welfare*
*Ottawa, Canada*

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*2*).

The February 1966 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. During this period strontium-89 and iodine-131 concentrations were below minimum detectable levels.

**Table 4. Stable elements and radionuclides in Canadian whole milk, February 1966**

| Station | Calcium (g/liter) | Potassium (g/liter) | Strontium-90 (pCi/liter) | Cesium-137 (pCi/liter) |
|---|---|---|---|---|
| Calgary | 1.08 | 1.5 | 23.3 | 66 |
| Edmonton | 1.12 | 1.5 | 21.9 | 62 |
| Ft. William | 1.10 | 1.6 | 30.7 | 71 |
| Fredericton | 1.09 | 1.5 | 29.8 | 76 |
| Halifax | 1.06 | 1.5 | 23.1 | 64 |
| Montreal | 1.10 | 1.6 | 16.7 | 47 |
| Ottawa | 1.12 | 1.6 | 14.3 | 36 |
| Quebec | 1.09 | 1.6 | 28.1 | 89 |
| Regina | 1.10 | 1.5 | 18.3 | 41 |
| St. John's, Nfld. | 1.11 | 1.5 | 28.1 | 89 |
| Saskatoon | 1.11 | 1.7 | 22.9 | 47 |
| Sault Ste. Marie | 1.10 | 1.6 | 26.5 | 80 |
| Toronto | 1.14 | 1.6 | 10.6 | 33 |
| Vancouver | 1.16 | 1.6 | 21.1 | 81 |
| Windsor | 1.08 | 1.4 | 9.5 | 32 |
| Winnipeg | 1.00 | 1.5 | 18.2 | 51 |
| Average | 1.09 | 1.6 | 21.4 | 60 |

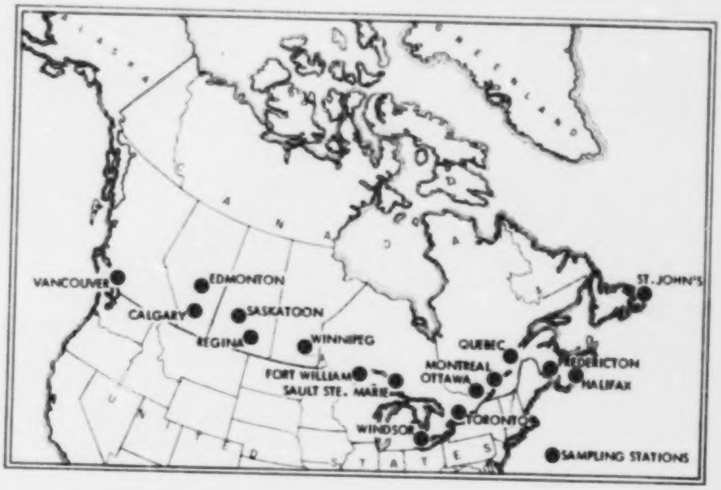

**Figure 3. Canadian Milk Sampling Network**

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[1] Prepared from February 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

137

## 3. Pan American Milk Sampling Program February 1966

*Pan American Health Organization and Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*3*).

Table 5 presents stable calcium and potassium, strontium-90, strontium-89, and cesium-137 monthly average concentrations. The monthly average iodine-131 and barium-140 concentrations in milk were less than 10 pCi/liter.

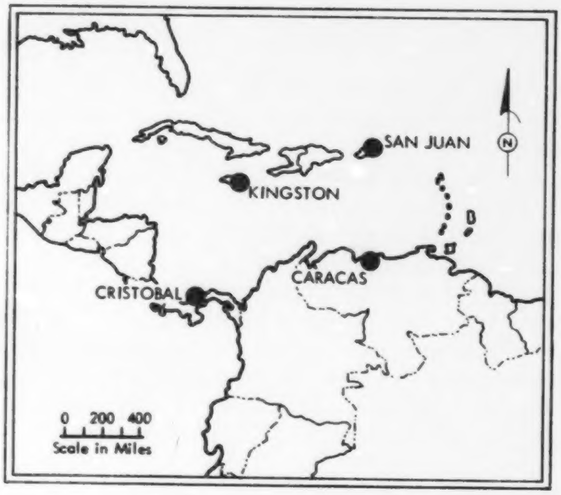

Figure 4. Pan American Milk Network

Table 5. PAHO stable elements and radionuclide concentrations in milk, February 1966

| Sampling station | Calcium (g/liter) | Potassium (g/liter) | Strontium-89 (pCi/liter) | Strontium-90 (pCi/liter) | Cesium-137 (pCi/liter) |
|---|---|---|---|---|---|
| Canal Zone: | | | | | |
| Cristobal | 1.11 | 1.5 | <5 | 3 | 25 |
| Jamaica: | | | | | |
| Kingston | NS | NS | NS | NS | NS |
| Mandeville | 1.08 | 1.22 | <5 | 7 | 95 |
| Montego Bay | NS | NS | NS | NS | NS |
| Puerto Rico: | | | | | |
| San Juan | 1.09 | 1.5 | <5 | 8 | 30 |
| Venezuela: | | | | | |
| Caracas | 1.14 | 1.31 | <5 | 4 | 10 |

NS, no sample collected.

## 4. Radiostrontium in milk July–September 1965[2]

*Health and Safety Laboratory U.S. Atomic Energy Commission*

In 1954, the Health and Safety Laboratory began monitoring strontium-90 in liquid whole milk in New York City to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York (1954), and at Mandan, North Dakota (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of quart samples of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged for reporting purposes. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used in cattle feeds. Because of its protein and fat content, this buttermilk powder is used primarily as a milk replacer or feed supplement for calves. The Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is a herd on the island of Oahu where the cows are on pasture throughout the year. Sampling at Mandan and Honolulu was discontinued at the end of June 1965.

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[2] Data summarized from "Fallout Program Quarterly Summary Report, HASL 171," available from Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151. Price $4.00.

**Table 6. Strontium-90 and calcium in liquid milk July–December 1965**

| Sampling station and periods | Calcium concentration (g/liter) | Strontium-90 concentration (pCi/liter) | Strontium-90/ calcium ratio (pCi/g) |
|---|---|---|---|
| *New York, New York* | | | |
| *1965* | | | |
| July | 1.01 | 18.2 | 18.0 |
| August | 10.77 | 16.6 | 21.6 |
| September | 1.04 | 17.1 | 16.5 |
| October | 1.00 | 17.6 | 17.6 |
| November | 10.77 | 12.3 | 16.0 |
| December | 0.98 | 16.8 | 17.1 |
| *Honolulu, Hawaii* | | | |
| *1965* | | | |
| July | NS | NS | NS |
| August | NS | NS | NS |
| September | NS | NS | NS |
| October | NS | NS | NS |
| November | NS | NS | NS |
| December | NS | NS | NS |

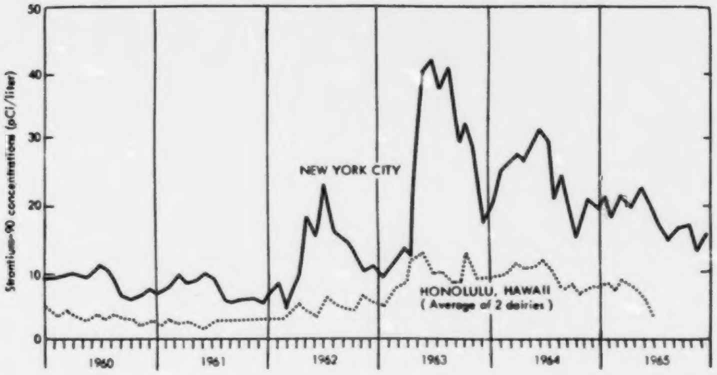

Figure 5. Strontium-90 in liquid milk samples

*Results and discussion*

The calcium and strontium-90 concentrations in liquid whole milk are presented in table 6, and the strontium-90 data are plotted in figure 5.

Strontium-90 concentrations are shown in powdered milk (table 7) and powdered buttermilk (table 8) and plotted in figure 6. The general decreasing trend in strontium-90 levels

**Table 7. Strontium-90 and calcium in powdered milk April–June 1965, and annual average strontium-90 concentrations in powdered milk, 1959–1964**

| Sampling station and month | Calcium concentration (g/kg) | Strontium-90 concentration (pCi/kg) | Strontium-90/ calcium ratio (pCi/g) |
|---|---|---|---|
| *Perry, New York* | | | |
| *1965* | | | |
| July | 8.78 | 132 | 15.1 |
| August | 8.88 | 115 | 12.9 |
| September | 8.50 | 99 | 11.6 |
| October | 8.63 | 94 | 10.9 |
| November | 8.61 | 101 | 11.7 |
| December | 8.82 | 104 | 11.7 |

### Table 8. Strontium-90 to calcium ratio in milk, 1954–1965

| Station and type of milk | Year | Strontium-90 to calcium ratio, pCi/g | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Average |
| New York, New York: liquid milk | 1954 | NS | NS | NS | NS | NS | 0.5 | 0.9 | 0.6 | 2.3 | 1.8 | 1.7 | 1.8 | — |
| | 1955 | 1.5 | 0.9 | 1.1 | 0.9 | 2.4 | 3.7 | 5.2 | 2.4 | 4.0 | 3.9 | 3.6 | 3.8 | 2.8 |
| | 1956 | 4.2 | 3.7 | 3.7 | 3.5 | 4.2 | NS | NS | NS | NS | NS | NS | NS | — |
| | 1957 | 3.2 | 4.1 | 3.8 | 3.7 | 4.0 | 5.5 | 6.6 | 4.6 | 4.9 | 5.7 | 4.7 | 2.9 | 4.5 |
| | 1958 | 3.6 | 4.0 | 3.2 | 4.1 | 3.9 | 10.2 | 11.3 | 10.9 | 10.6 | 9.9 | 11.7 | 8.2 | 7.6 |
| | 1959 | 8.2 | 8.4 | 8.0 | 7.7 | 13.4 | 24.2 | 14.1 | 10.7 | 9.8 | 8.3 | 10.2 | 9.2 | 11.0 |
| | 1960 | 8.1 | 8.9 | 9.1 | 8.7 | 8.8 | 10.1 | 9.8 | 8.6 | 6.1 | 6.1 | 5.9 | 6.3 | 8.0 |
| | 1961 | 6.7 | 7.3 | 8.1 | 6.5 | 8.1 | 8.4 | 7.0 | 5.4 | 5.2 | 6.0 | 6.1 | 5.7 | 6.7 |
| | 1962 | 5.7 | 6.1 | 4.0 | 9.1 | 14.8 | 14.5 | 23.2 | 17.4 | 15.3 | 13.6 | 10.3 | 10.9 | 12.1 |
| | 1963 | 8.3 | 11.2 | 13.4 | 12.1 | 40.6 | 42.4 | 35.8 | 40.5 | 27.1 | 29.6 | 25.9 | 20.7 | 25.6 |
| | 1964 | 21.1 | 23.9 | 27.2 | 26.1 | 30.8 | 30.9 | 22.0 | 24.9 | 17.1 | 14.8 | 19.7 | 19.3 | 23.2 |
| | 1965 | 20.8 | 18.0 | 21.1 | 19.0 | 22.9 | 18.0 | 18.0 | 21.6 | 16.5 | 17.6 | 16.0 | 17.1 | 19.1 |
| Perry, New York: powdered whole milk | 1954 | NS | NS | NS | 0.5 | 1.2 | 1.3 | 1.5 | 1.2 | 1.5 | 1.4 | 1.1 | 0.6 | — |
| | 1955 | 2.5 | 0.8 | 0.8 | 0.3 | 1.9 | 2.5 | 1.9 | 2.0 | 1.5 | 2.8 | 2.5 | 3.3 | 1.9 |
| | 1956 | 2.3 | 2.0 | 2.0 | 2.9 | 2.8 | 3.0 | 2.7 | 3.1 | 4.9 | 5.4 | 5.6 | 3.2 | 3.3 |
| | 1957 | 3.8 | 4.0 | 3.0 | 3.1 | 3.9 | 4.6 | 4.7 | 4.2 | 4.3 | 3.6 | 4.4 | 2.6 | 3.8 |
| | 1958 | 3.4 | 3.6 | 3.0 | 3.0 | 5.0 | 5.4 | 8.6 | 7.2 | 6.6 | 7.8 | 10.0 | 6.9 | 5.9 |
| | 1959 | 8.1 | 7.6 | 6.6 | 7.2 | 8.9 | 8.9 | 10.0 | 7.8 | 6.1 | 10.5 | 7.0 | 7.7 | 8.0 |
| | 1960 | 8.7 | 8.6 | 7.3 | 7.7 | 7.3 | 7.1 | 7.7 | 5.5 | 5.0 | 5.1 | 4.2 | 4.8 | 6.6 |
| | 1961 | 6.5 | 7.0 | 6.5 | 7.2 | 6.6 | 5.9 | 6.3 | 5.8 | 6.5 | 5.8 | 5.1 | 5.9 | 6.2 |
| | 1962 | 5.2 | 5.0 | 5.6 | 5.6 | 8.8 | 13.0 | 21.7 | 15.6 | 14.2 | 13.6 | 12.8 | 12.3 | 11.1 |
| | 1963 | 12.5 | 11.4 | 11.9 | 11.8 | 18.3 | 30.5 | 30.1 | 27.1 | 30.6 | 30.1 | 22.2 | 22.1 | 21.6 |
| | 1964 | 20.1 | 21.7 | 20.9 | 21.0 | 19.3 | 24.2 | 28.0 | 22.1 | 18.8 | 16.0 | 14.7 | 18.0 | 20.4 |
| | 1965 | 17.7 | 14.2 | 19.0 | 18.3 | 16.9 | 13.3 | 15.1 | 12.9 | 11.6 | 10.9 | 11.7 | 11.7 | 14.4 |
| Honolulu, Hawaii: liquid milk Dairy A | 1959 | NS | NS | NS | NS | NS | NS | NS | 6.1 | 3.9 | 6.8 | 3.7 | 3.3 | — |
| | 1960 | 3.4 | 3.5 | 3.6 | 4.3 | 2.2 | 2.7 | 2.4 | 2.5 | 2.3 | 2.7 | 1.8 | 3.2 | 2.9 |
| | 1961 | 1.8 | 2.4 | 1.9 | 2.0 | 2.1 | 1.6 | 1.5 | 2.4 | 1.5 | 2.2 | 3.2 | 3.1 | 2.1 |
| | 1962 | 2.4 | 2.1 | 2.6 | 3.9 | 4.5 | 2.4 | 4.2 | 3.1 | 5.5 | 4.8 | 2.4 | 3.7 | 3.5 |
| | 1963 | 4.8 | 4.3 | 6.0 | 6.4 | 7.3 | 10.1 | 8.9 | 6.5 | 7.4 | 8.5 | 6.1 | 6.8 | 6.9 |
| | 1964 | 6.9 | 7.2 | 8.3 | 8.4 | 8.6 | 11.2 | 9.8 | 6.3 | 7.3 | 7.2 | 7.1 | 7.2 | 8.0 |
| | 1965 | 7.0 | 6.8 | 7.7 | 7.3 | 6.7 | 4.7 | NS | NS | NS | NS | NS | NS | — |
| Dairy B | 1959 | NS | NS | NS | NS | NS | NS | NS | 5.8 | 4.8 | 6.0 | 4.5 | 5.4 | — |
| | 1960 | 4.2 | 3.5 | 5.2 | 3.3 | 3.6 | 3.9 | 3.6 | 3.8 | 3.4 | 3.2 | 2.7 | 2.2 | 3.6 |
| | 1961 | 2.7 | 3.5 | 3.1 | 2.8 | 1.9 | 2.6 | 2.2 | 2.5 | 3.9 | 3.2 | 2.1 | 2.2 | 2.7 |
| | 1962 | 2.8 | 3.6 | 3.6 | 5.8 | 3.8 | 3.9 | 7.7 | 6.4 | 3.0 | 3.9 | 7.8 | 7.5 | 5.0 |
| | 1963 | 4.8 | 7.0 | 9.3 | 9.5 | 11.9 | 8.8 | 9.0 | 8.6 | 7.3 | 16.4 | 8.6 | 8.0 | 9.1 |
| | 1964 | 8.7 | 9.2 | 13.1 | 11.1 | 11.9 | 11.1 | 9.6 | 7.0 | 7.5 | 6.3 | 8.5 | 8.0 | 9.3 |
| | 1965 | 8.8 | 8.3 | 10.2 | 7.8 | 6.8 | 4.4 | NS | NS | NS | NS | NS | NS | — |
| Mandan, North Dakota: powdered buttermilk | 1955 | NS | NS | NS | NS | 7.3 | 9.2 | 6.3 | 5.8 | 4.7 | 6.9 | 7.4 | 10.0 | — |
| | 1956 | 3.5 | 8.1 | 11.0 | 9.6 | 17.0 | 8.7 | 6.6 | 8.6 | 10.7 | 8.9 | 5.1 | 7.4 | 8.8 |
| | 1957 | 4.4 | 8.2 | 7.4 | 6.8 | 9.8 | 10.9 | 17.3 | 32.7 | 24.2 | 25.6 | 29.6 | 20.1 | 16.4 |
| | 1958 | 15.2 | 16.5 | 15.6 | 21.6 | 21.3 | 26.3 | 26.7 | 20.2 | 19.4 | 20.8 | 23.1 | 19.2 | 20.5 |
| | 1959 | 20.8 | 18.4 | 23.9 | 27.8 | 47.5 | 37.9 | 22.2 | 24.0 | 16.6 | 20.9 | 23.5 | 25.0 | 25.7 |
| | 1960 | 22.6 | 21.8 | 22.5 | 24.4 | 21.4 | 11.5 | 9.6 | 10.0 | 9.1 | 8.1 | 9.1 | 10.6 | 15.0 |
| | 1961 | 10.4 | 11.6 | 10.9 | 12.2 | 12.0 | 9.6 | 7.3 | 7.4 | 5.1 | 8.0 | 9.4 | 8.5 | 9.4 |
| | 1962 | 7.7 | 7.8 | 16.0 | 20.6 | 28.7 | 28.8 | 33.1 | 26.8 | 35.9 | 31.5 | 28.8 | 31.1 | 24.7 |
| | 1963 | 26.6 | 31.3 | 30.0 | 42.2 | 105 | 56.5 | 53.2 | 59.2 | 61.0 | 83.7 | 75.6 | 68.6 | 57.7 |
| | 1964 | 68.3 | 81.8 | 73.2 | 81.2 | 100 | 67.5 | 44.8 | 34.8 | 41.0 | 50.0 | 53.0 | 56.8 | 62.7 |
| | 1965 | 54.6 | 50.0 | 61.8 | 60.7 | 66.3 | 32.4 | NS | NS | NS | NS | NS | NS | — |

NS, no sample collected

can be expected. The current powdered milk results are shown in figure 6 in relation to results since January 1960. It has been assumed that 0.1 kilogram of powdered milk is used to prepare a liter of liquid milk.

A summary of strontium-90 to calcium ratio data in milk for Perry and New York City, New York; Honolulu, Hawaii; and Mandan, North Dakota, since the inception of the sampling programs is given in table 8.

140

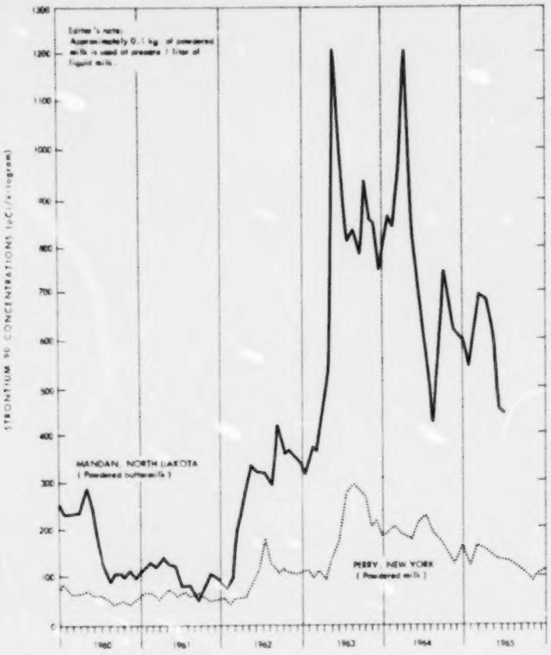

Figure 6. Strontium-90 in powdered milk samples

Recent coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| April–June 1963 | January 1964 |
| July–September 1963 | April 1964 |
| Ocober–December 1963 | July 1964 |
| January–December 1964 | June 1965 |
| January–March 1965 | September 1965 |
| April–June 1965 | March 1966 |

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH, and DIVISION OF ENVIRONMENTAL ENGINEERING AND FOOD PROTECTION. Milk surveillance, Pasteurized Milk Network, August 1965. Rad Health Data 6:677–681 (December 1965).

(*2*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION, OTTAWA, CANADA. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

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## STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed to a state of comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein, while not inclusive, are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

| State milk network | Period reported | Last presented |
|---|---|---|
| Colorado | October–December 1964 | April 1965 |
| Connecticut | April–September 1965 | February 1966 |
| Florida | July–December 1965 | April 1966 |
| Indiana | July–September 1965 | February 1966 |
| Michigan | July–September 1965 | February 1966 |
| Minnesota | January–June 1965 | January 1966 |
| New York | April–June 1965 | January 1966 |
| Oklahoma | August–December 1965 | April 1966 |
| Pennsylvania | July–September 1965 | February 1966 |
| Texas | April–December 1965 | April 1966 |

## 1. California Milk Network October–December 1965 and Annual Summaries 1964 and 1965

*Division of Environmental Sanitation*
*State of California*
*Department of Public Health*

Surveillance of specific radionuclides in milk is one phase of California's Department of Health program of radiation control. This milk monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health. With the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (figure 1). The original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

Strontium–89 and strontium–90 concentrations are determined radiochemically.

Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented earlier (*2*).

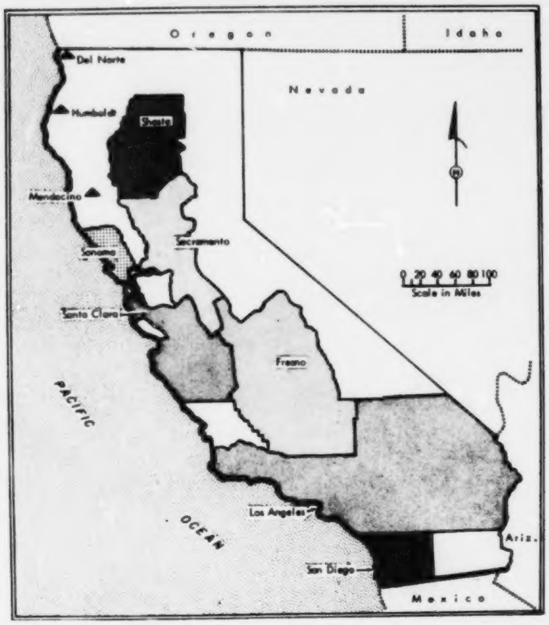

Figure 1. California milksheds

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period October to December 1965.

Table 1. Stable elements and radionuclides in California milk October–December 1965

| Element and month | Del Norte | Fresno | Humboldt | Los Angeles | Mendocino | Sacramento | San Diego | Santa Clara | Shasta | Sonoma | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Calcium (g/liter) | | | | | | | | | | | |
| October | 1.40 | 1.26 | 1.35 | 1.18 | 1.26 | 1.25 | 1.20 | 1.11 | 1.15 | 1.29 | 1.25 |
| November | 1.28 | 1.18 | 1.21 | 1.06 | 1.25 | 1.22 | 1.05 | 1.08 | 1.11 | 1.12 | 1.16 |
| December | 1.32 | 1.23 | 1.24 | 1.07 | 1.29 | 1.21 | 1.10 | 1.13 | 1.18 | 1.18 | 1.20 |
| Potassium-40 (pCi/liter) | | | | | | | | | | | |
| October | 1,130 | 1,180 | 1,140 | 1,360 | 1,280 | 1,210 | 1,190 | 1,170 | 1,190 | 1,170 | 1,200 |
| November | 1,170 | 1,190 | 1,060 | 1,250 | 1,240 | 1,260 | 1,220 | 1,170 | 1,260 | 1,190 | 1,200 |
| December | 1,110 | 1,180 | 1,160 | 1,250 | 1,240 | 1,290 | 1,210 | 1,130 | 1,240 | 1,240 | 1,200 |
| Strontium-89 (pCi/liter) | | | | | | | | | | | |
| October | [a]0.4 | ND | [a]0.7 | NA | [a]0.1 | ND | [a]1.1 | ND | 0.3 | NA | 0.3 |
| November | ND | 0.8 | 0.7 | ND | 0.4 | ND | ND | 0.2 | ND | 0.5 | 0.3 |
| December | 2.7 | 0.6 | 0.4 | [a]0.6 | ND | ND | ND | ND | ND | 1.5 | 0.6 |
| Strontium-90 (pCi/liter) | | | | | | | | | | | |
| October | 17 | 2.8 | 5 | 3.0 | 3.8 | 4.0 | 1.5 | 2.3 | 4.4 | 5.0 | 4.9 |
| November | 26 | 2.6 | 7 | 4.5 | 5.4 | 4.5 | 2.1 | 3.0 | 5.2 | 3.7 | 6.4 |
| December | 24 | 2.5 | 10 | 3.1 | 4.4 | 4.0 | 3.7 | 3.0 | 5.4 | 5.0 | 6.5 |
| Cesium-137 (pCi/liter) | | | | | | | | | | | |
| October | 25 | [a]9 | 13 | 26 | 12 | 14 | 12 | 17 | 22 | 28 | 18 |
| November | 43 | 15 | 17 | 12 | 8 | 18 | 11 | 18 | 17 | 24 | 18 |
| December | 72 | 19 | 35 | 18 | 18 | 21 | 14 | 12 | 29 | 31 | 27 |

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.
NA, no analysis performed
ND, below detectable levels.

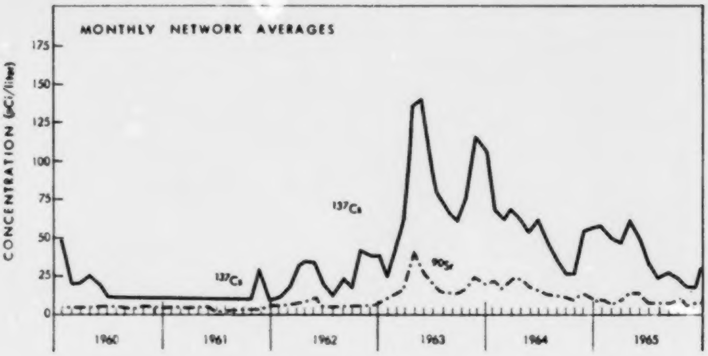

**Figure 2. Radionuclide concentrations in California milk, 1960–1965**

**Table 2. Monthly average radionuclide concentrations in California milk 1964–1965**

| Month and year | Calcium (g/liter) | Potassium (pCi/liter) | Strontium-89 (pCi/liter) | Strontium-90 (pCi/liter) | Cesium-137 (pCi/liter) |
|---|---|---|---|---|---|
| *1964* | | | | | |
| January | 1.20 | 1,260 | 8 | 20 | 67 |
| February | 1.22 | 1,220 | 8 | 16 | 62 |
| March | 1.21 | 1,230 | 4 | 21 | 67 |
| April | 1.20 | 1,260 | 1.9 | 22 | 59 |
| May | 1.22 | 1,240 | 0.7 | 17 | 52 |
| June | 1.17 | 1,260 | 1.4 | 15 | 60 |
| July | 1.18 | 1,230 | 2 | 12 | 43 |
| August | 1.14 | 1,220 | ND | 11 | 33 |
| September | 1.19 | 1,180 | 1 | 9 | 22 |
| October | 1.15 | 1,200 | NA | 8 | 22 |
| November | 1.23 | 1,140 | 6.8 | 11 | 51 |
| December | 1.25 | 1,150 | 6.0 | 10 | 55 |
| *1965* | | | | | |
| January | 1.22 | 1,210 | NA | 12 | 58 |
| February | 1.22 | 1,260 | NA | 11 | 50 |
| March | 1.20 | 1,220 | NA | 12 | 46 |
| April | 1.21 | 1,190 | 0.9 | 14 | 61 |
| May | 1.33 | 1,230 | 0.4 | 14 | 49 |
| June | 1.21 | 1,200 | 0.4 | 9 | 32 |
| July | 1.17 | 1,200 | 0.9 | 8 | 22 |
| August | 1.18 | 1,210 | 0.4 | 6 | 24 |
| September | 1.23 | 1,000 | 0.3 | 5 | 20 |
| October | 1.25 | 1,202 | 0.3 | 4.9 | 18 |
| November | 1.16 | 1,200 | 0.3 | 6.4 | 18 |
| December | 1.20 | 1,204 | 0.6 | 6.5 | 27 |

ND, no detectable activity
NA, no analysis performed

Network average strontium-90 and cesium-137 concentrations are presented graphically in figure 2. Superimposed upon normal seasonal variations is a decreasing trend since the peak which occurred in the spring of 1963. A summary of monthly average concentrations in milk is given in table 2 for 1964 and 1965.

Previous coverage in *Radiological Health Data and Reports*:

| Period | Issue |
|---|---|
| January–March 1964 | September 1964 |
| April–June 1964 | December 1964 |
| July–September 1964 | March 1965 |
| October–December 1964 | June 1965 |
| January–March 1965 | September 1965 |
| April–June 1965 | December 1965 |
| July–September 1965 | March 1966 |

## 2. Oregon Milk Network
## October–December and Annual Summary 1965

*Division of Sanitation and Engineering*
*Oregon State Board of Health*

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program, routine milk samples are collected at eight major production areas (figure 3), which supply 90 percent of the milk distributed in Oregon. Currently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture except in the Portland area where weekly samples are collected by the city of Portland. The milk-sampling frequency is accelerated to a weekly basis in areas where iodine-131 con-

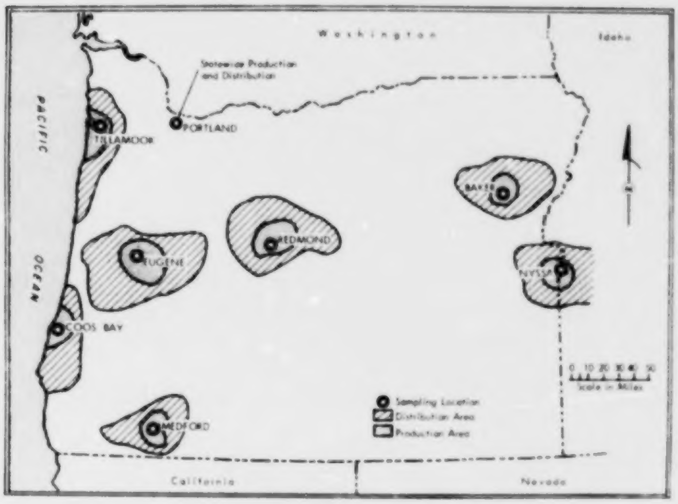
Washington
Idaho
Statewide Production and Distribution
PACIFIC
OCEAN
PORTLAND
TILLAMOOK
BAKER
REDMOND
EUGENE
NYSSA
COOS BAY
MEDFORD
0 10 20 30 40 50
Scale in Miles
Sampling Location
Distribution Area
Production Area
California
Nevada

Figure 3. Oregon milk production and distribution areas

centrations exceed 100 pCi/liter, or where cesium-137 concentrations exceed 500 pCi/liter. Strontium-90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium-90 concentrations are determined using a trichloracetic acid analytical procedure (*3*). Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry (*4*).

Table 3 gives the strontium-90 and cesium-137 concentration in pasteurized milk from October through December 1965. These data are presented graphically in figure 4. Iodine-131 and barium-140 concentrations remained below minimum detectable levels of 15 pCi/liter.

**Table 3. Radionuclide concentrations in Oregon milk October-December 1965**

| Location | Sampling frequency | Strontium-90 (pCi/liter) | | | Cesium-137 (pCi/liter) | | |
|---|---|---|---|---|---|---|---|
| | | Oct | Nov | Dec | Oct | Nov | Dec |
| Baker | M | NA | 10 | NA | 30 | 25 | 25 |
| Coos Bay | M | NA | 19 | NA | 45 | 60 | 50 |
| Eugene | M | NA | 11 | NA | 25 | 30 | 35 |
| Medford | M | NA | 15 | NA | 75 | 45 | 20 |
| Nyssa | M | NA | 12 | NA | 20 | 25 | 25 |
| Portland composite | W | 12 | 13 | 11 | 38 | 41 | 36 |
| Portland local | W | NA | 16 | NA | 45 | 51 | 50 |
| Redmond | M | NA | 10 | NA | 40 | 50 | 40 |
| Tillamook | M | NA | 29 | NA | 50 | 90 | 65 |
| Average | — | 12 | 15 | 11 | 41 | 46 | 37 |

M, sampled monthly
NA, no analysis performed
W, sampled weekly

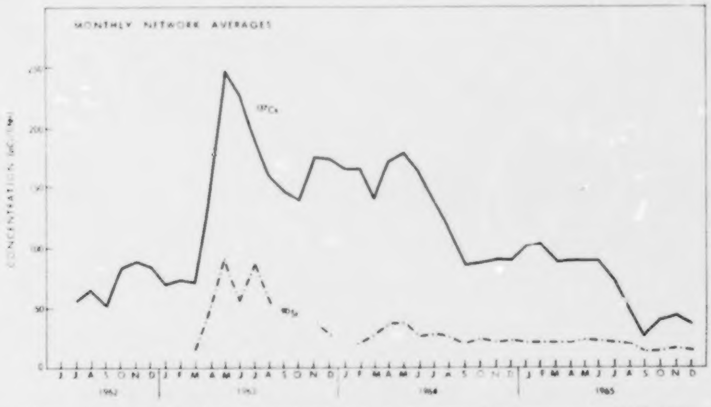

Figure 4. Radionuclide concentrations in Oregon milk network, 1962-1965

A summary of radionuclide concentrations in Oregon pasteurized milk is presented in table 4 for 1965.

**Table 4. Monthly average radionuclide concentrations in Oregon pasteurized milk, 1965**

| 1965 | Concentration, pCi/liter | |
|---|---|---|
| | Strontium-90 | Cesium-137 |
| January | 21 | 101 |
| February | NA | 103 |
| March | 21 | 89 |
| April | NA | 90 |
| May | 24 | 90 |
| June | NA | 90 |
| July | 19 | 66 |
| August | 13 | 55 |
| September | 15 | 40 |
| October | 12 | 41 |
| November | 15 | 46 |
| December | 11 | 37 |

NA, no analysis

**Recent coverage in *Radiological Health Data and Reports*:**

| Period | Issue |
|---|---|
| October–December 1964 and Summary 1962–1964 | June 1965 |
| January–March 1965 | August 1965 |
| April–June 1965 | December 1965 |
| July–September 1965 | March 1966 |

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## 3. Washington Milk Network October-December and Annual Summaries for 1964 and 1965

*Air Sanitation and Radiation Control Section*
*State of Washington Department of Health*

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 5 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented earlier (*5*).

Selected samples are analyzed radiochemically for strontium-90. Potassium-40, iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 5 presents monthly radionuclide concentrations in Washington raw milk for October through December 1965. During this period, iodine-131 and barium-140 concentrations remained below minimum detectable levels. Monthly average strontium-90 and cesium-137 concentrations are presented graphically in figure 6, so as to display general trends.

Zinc-65 was observed in the Benton-Franklin area on three occasions during this period (table 6). This nuclide has periodically appeared in this area as a result of the irrigation of some pasture land with Columbia River water which has been shown to contain this contaminant.

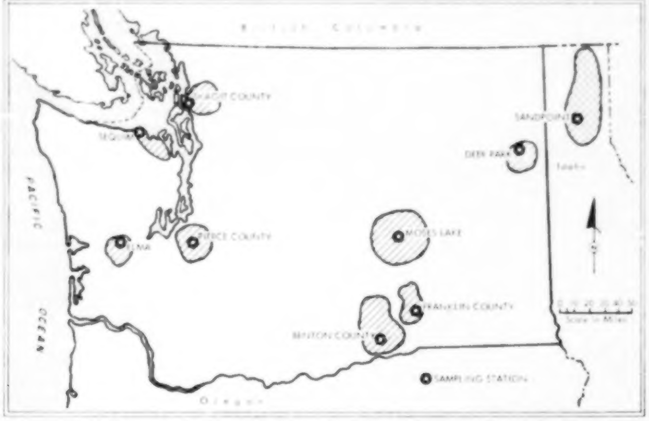

Figure 5. Washington milksheds and sampling locations

**Table 5. Radionuclide concentrations in Washington milk October–December 1965**

| Sampling location | Potassium-40, pCi/liter | | |
|---|---|---|---|
| | October | November | December |
| Benton County | 1,250 | NS | 1,290 |
| Deer Park | 1,280 | 1,210 | 1,350 |
| Elma | 1,250 | 1,220 | 1,330 |
| Franklin County | NS | 1,110 | NS |
| Moses Lake | 1,330 | 1,260 | 1,300 |
| Pierce County | 1,170 | 1,260 | 1,260 |
| Sandpoint | 1,300 | 1,140 | 1,260 |
| Sequim | 1,040 | 1,130 | 1,350 |
| Skagit County | 1,030 | 1,250 | 1,140 |
| Average | 1,210 | 1,200 | 1,290 |
| | Strontium-90, pCi/liter | | |
| Benton County | 6 | NS | 6 |
| Deer Park | 14 | 15 | 15 |
| Elma | 22 | 10 | 10 |
| Franklin County | NS | 6 | NS |
| Moses Lake | 5 | 7 | 8 |
| Pierce County | 12 | 16 | 8 |
| Sandpoint | 27 | 28 | 36 |
| Sequim | 8 | 9 | 8 |
| Skagit County | 18 | 18 | 16 |
| Average | 14 | 14 | 13 |
| | Cesium-137, pCi/liter | | |
| Benton County | 18 | NS | 24 |
| Deer Park | 40 | 42 | 50 |
| Elma | 49 | 45 | 24 |
| Franklin County | NS | 22 | NS |
| Moses Lake | 20 | 18 | 33 |
| Pierce County | 45 | 54 | 29 |
| Sandpoint | 79 | 82 | 94 |
| Sequim | 34 | 31 | 20 |
| Skagit county | 56 | 29 | 45 |
| Average | 43 | 40 | 40 |

NS, no sample collected.

**Table 6. Milk samples in Washington State containing zinc-65**

| Sampling location | Date (1965) | Zinc-65 (pCi/liter) |
|---|---|---|
| Benton County | October 4 | 38 |
| Franklin County | November 3 | 98 |
| Benton County | December 10 | 44 |

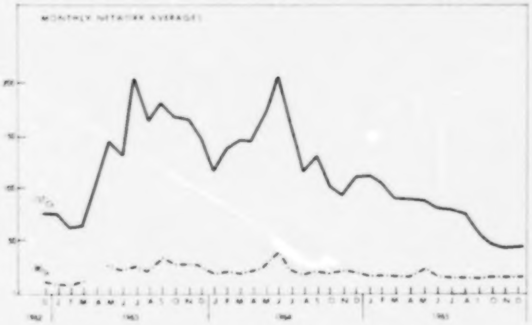

Figure 6. Radionuclides in Washington milk, December 1962–December 1965

A summary of the radionuclide concentrations in Washington raw milk is presented in table 7 for 1964 and 1965.

**Table 7. Network average radionuclide concentrations in Washington raw milk, 1964–1965**

| Year and month | Concentration, pCi/liter | | |
|---|---|---|---|
| | Potassium-40 | Strontium-90 | Cesium-137 |
| *1964* | | | |
| January | 1,220 | 19 | 119 |
| February | 1,200 | 26 | 139 |
| March | 1,160 | 20 | 146 |
| April | 1,160 | 22 | 145 |
| May | 1,180 | 29 | 146 |
| June | 1,140 | 39 | 205 |
| July | 1,210 | 21 | 169 |
| August | 1,160 | 18 | 117 |
| September | 1,210 | 20 | 131 |
| October | 1,200 | 19 | 104 |
| November | 1,180 | 21 | 107 |
| December | 1,210 | 19 | 111 |
| *1965* | | | |
| January | 1,180 | 18 | 115 |
| February | 1,200 | 18 | 109 |
| March | 1,220 | 18 | 93 |
| April | 1,190 | 17 | 93 |
| May | 1,200 | 24 | 90 |
| June | 1,170 | 19 | 81 |
| July | 1,250 | 15 | 77 |
| August | 1,200 | 15 | 75 |
| September | 1,210 | 13 | 56 |
| October | 1,210 | 14 | 43 |
| November | 1,200 | 14 | 40 |
| December | 1,290 | 13 | 40 |

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| December 1962–December 1963 | May 1964 |
| January–June 1964 | February 1965 |
| July–December 1964 | May 1965 |
| January–June 1965 | November 1965 |
| July–September 1965 | March 1966 |

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# FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. While not based on probability sampling, these networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs previously covered in *Radiological Health Data and Reports* include:

| Program | Period reported | Last presented |
|---|---|---|
| Institutional Total Diet | July–September 1965 | May 1966 |
| Teenage Diet | February–November 1964 | July 1965 |
| California Diet | January–April 1965 | March 1966 |

## 1. Strontium–90 in Tri-City Diets August–October 1965[1]

*Health and Safety Laboratory*
*U.S. Atomic Energy Commission*

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium–90. Fourteen of the diet categories are analyzed on a quarterly basis. Eggs, poultry, fresh fish, shellfish, and meat are purchased quarterly, but analyzed annually. This policy was initiated in 1965 due to the lower concentrations of strontium–90 in these food categories. The contribution of these five diet categories to the total annual intake of strontium–90 over the last 4 years has been approximately 5 percent. Therefore, this figure is used to calculate the contribution of these food categories to the total diet strontium–90 intake. These values are added to the contributions of the other 14 food categories to obtain quarterly estimates of annual strontium–90 intake at the three cities. Consumption figures used are based upon data from the Department of Agriculture (*1*).

Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this material. Details

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[1] Data from Fallout Program Quarterly Summary Report, HASL 171. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

147

of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results of the August to October 1965 sampling are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1. A discussion of cesium-137 intakes from the Tri-City Diet Study is presented elsewhere (*4*).

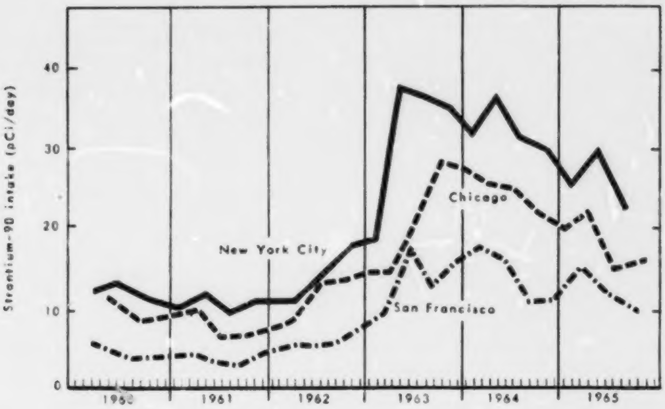

**Figure 1. Daily intake of strontium-90 in Tri-City diets 1960–October 1965**

**Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet August–October 1965**

| Food category | Diet (kg/yr) | Calcium (g/yr) | New York City, August 1965 | | Chicago, October 1965 | | San Francisco, September 1965 | |
|---|---|---|---|---|---|---|---|---|
| | | | (pCi/kg) | (pCi/yr) | (pCi/kg) | (pCi/yr) | (pCi/kg) | (pCi/yr) |
| Bakery products | 37 | 37.0 | 29.5 ±1.2 | 1,092 | 15.6 ±1.1 | 577 | 12.2 ±1.1 | 451 |
| Whole grain products | 11 | 10.0 | 36.9 ±1.2 | 406 | 35.6 ±1.7 | 392 | 30.8 ±1.2 | 339 |
| Fresh vegetables | 43 | 15.0 | 12.9 ±0.4 | 555 | 13.1 ±0.5 | 563 | 2.4 ±0.3 | 103 |
| Root vegetables | 17 | 6.1 | 10.3 ±0.4 | 175 | 18.3 ±0.5 | 311 | 6.5 ±0.4 | 111 |
| Milk | 221 | 234.4 | 16.6 ±0.5 | 3,669 | 12.0 ±0.5 | 2,652 | 4.7 ±0.2 | 1,039 |
| Flour | 43 | 8.6 | 22.2 ±0.4 | 955 | 13.9 ±0.4 | 598 | 6.0 ±0.2 | 258 |
| Macaroni | 3 | 0.7 | 14.6 ±0.4 | 44 | 14.8 ±0.8 | 44 | 12.6 ±0.4 | 38 |
| Rice | 3 | 1.1 | 2.2 ±0.4 | 7 | 6.6 ±0.5 | 20 | 5.3 ±0.4 | 16 |
| Dried beans | 3 | 2.9 | 25.2 ±0.4 | 76 | 19.5 ±1.5 | 59 | 22.7 ±1.9 | 68 |
| Fresh fruit | 68 | 12.6 | 3.4 ±0.3 | 231 | 1.8 ±0.2 | 122 | 4.4 ±0.3 | 299 |
| Potatoes | 45 | 5.8 | 1.0 ±0.5 | 45 | 0.6 ±0.1 | 27 | 13.2 ±0.8 | 594 |
| Canned fruit | 26 | 1.3 | 3.2 ±0.1 | 83 | 4.1 ±0.2 | 107 | 1.7 ±0.1 | 44 |
| Fruit juices | 19 | 1.7 | 6.4 ±0.3 | 122 | 7.0 ±0.3 | 133 | 3.9 ±0.2 | 74 |
| Canned vegetables | 20 | 4.2 | 16.9 ±0.5 | 388 | 15.2 ±0.7 | 394 | 1.2 ±0.6 | 24 |
| Meat, fish, poultry, shellfish, and eggs | 99 | 42.0 | | [a] 410 | | [a] 311 | | [a] 182 |
| Annual intake | --- | 383 | --- | 8,208 | --- | 6,220 | --- | 3,640 |
| pCi strontium-90/g calcium | | | | 21.4 | | 16.2 | | 9.5 |

[a] Estimated as 5 percent of total intake.

**Previous coverage in *Radiological Health Data and Reports*:**

| Period | Issue | Period | Issue |
|---|---|---|---|
| Sixteenth Sampling (February 1964–April 1964) | December 1964 | Nineteenth Sampling (November 1964–January 1965) | September 1965 |
| Seventeenth Sampling (July–September 1964) | March 1965 | Twentieth Sampling (February–April 1965) | December 1965 |
| Eighteenth Sampling (August–October 1964) | June 1965 | Twenty first Sampling (May–July 1965) | March 1966 |

## 2. Estimated daily intake of radionuclides in Califoria diets, May–August 1965

*Bureau of Radiological Health*
*California State Department of Public Health*

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (5).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest.

Hospitals were chosen as the source of diet samples under the hypothesis of their being as "reasonably representative" as any other. General hospitals exist in each of the selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

### *Sampling procedure*

In general, the sampling procedure is the same at each hospital. Samples are collected once every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

### *Analytical procedures*

After weighing at the laboratory, each sample is homogenized, dried, and ashed prior to determination of stable calcium, potassium, strontium, and sodium.

The radiochemical analyses are based upon three basic procedures: chemical separations of strontium–89 and strontium–90; analysis of radium–226; and gamma spectrometry of the entire wet sample.

### *Data and discussion*

The resultant estimates of daily intake of radionuclides in the California diets are given in table 2 for May through June 1965, and table 3 for July through August 1965.

**Table 2. Estimated daily intake of radionuclides in California diets, May–June 1965 [a]**

| City | Kg/capita/day [b] | pCi/capita • day | | | | | | Grams/capita • day | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $^{90}$Sr | $^{226}$Ra | $^{137}$Cs | $^{95}$Zr | $^{54}$Mn | $^{141}$Ce-$^{144}$Ce | K [c] | Na | Ca | Stable Sr [d] |
| Bakersfield | 2.1 | 9 | 0.5 | 84 | 6 | 0 | 0 | 2.5 | 3.3 | 0.0 | 0.001 |
| Berkeley | 2.7 | 18 | 0.3 | 82 | 7 | 5 | 3 | 2.8 | 5.3 | 0.9 | NA |
| Bishop | 1.8 | 11 | 0.3 | 65 | 7 | 0 | 0 | 2.2 | 3.7 | 0.6 | 0.001 |
| Brawley | 2.3 | 8 | 0.5 | NA | NA | NA | NA | 2.8 | 4.5 | 0.6 | 0.003 |
| Crescent City | 2.1 | 7 | 0.2 | 106 | 14 | 0 | 0 | 1.5 | 2.4 | 0.6 | 0.001 |
| Eureka | 1.7 | 16 | 0.5 | 77 | 4 | 0 | 4 | 4.3 | 3.1 | 0.8 | NA |
| Fresno | 2.5 | 12 | 0.9 | 0 | 0 | 0 | 0 | 2.5 | 4.7 | 1.2 | NA |
| Los Angeles | 2.7 | 11 | 0.4 | 78 | 5 | 0 | 1 | 2.3 | 3.0 | 0.1 | 0.001 |
| Needles | 2.2 | 9 | 0.4 | 67 | 6 | 0 | 6 | 2.0 | 3.0 | 0.7 | 0.001 |
| Quincy | 1.7 | 14 | 0.5 | 57 | 8 | 0 | 2 | 2.3 | 3.0 | 0.7 | 0.001 |
| Redding | 2.0 | 13 | 0.2 | 82 | 5 | 0 | 2 | 2.0 | 4.0 | 0.9 | 0.001 |
| Sacramento | 2.8 | 23 | 0.9 | 90 | 7 | 0 | 0 | 3.3 | 6.8 | 1.3 | 0.004 |
| Salinas | 2.4 | 16 | 0.8 | 63 | 7 | 0 | 0 | 4.0 | 8.0 | 1.2 | 0.008 |
| San Bernardino | 2.0 | 9 | 0.5 | 48 | 4 | 0 | 0 | 2.3 | 6.2 | 1.4 | 0.001 |
| San Diego | 2.2 | 14 | 0.7 | 55 | 0 | 0 | 1 | 3.0 | 5.0 | 1.0 | 0.006 |
| San Luis Obispo | 1.3 | 8 | 0.3 | 40 | 3 | 0 | 0 | 2.2 | 3.0 | 0.6 | 0.001 |
| Santa Barbara | 2.1 | 11 | 0.3 | 63 | 7 | 3 | 7 | 2.7 | 4.0 | 0.8 | 0.001 |
| Santa Rosa | 2.3 | 13 | 0.2 | 67 | 9 | 0 | 0 | 2.6 | 3.1 | 1.0 | 0.001 |
| Susanville | 1.6 | 12 | 0.3 | 71 | 10 | 0 | 0 | 2.0 | 5.0 | 0.6 | 0.001 |
| Ukiah | 2.0 | 17 | 1.0 | 88 | 11 | 0 | 0 | 2.4 | 2.3 | 1.5 | 0.001 |

[a] Based on analyses of hospital standard diets located in listed cities. Strontium-89 was not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] Stable strontium consists of $^{88}$Sr – 82.7 percent; $^{87}$Sr – 7.0 percent; $^{86}$Sr – 9.8 percent; $^{84}$Sr – 0.5 percent; total – 100 percent.
NA, no analysis performed.

149

**Table 3. Estimated daily intake of radionuclides in California diets, July–August 1965** [a]

| City | Kg/capita/day [b] | pCi/capita • day | | | | | | Grams/capita • day | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $^{90}Sr$ | $^{226}Ra$ | $^{137}Cs$ | $^{95}Zr$ | $^{54}Mn$ | $^{141}Ce$-$^{144}Ce$ | K [c] | Na | Ca | Stable Sr [d] |
| Bakersfield | 2.2 | 8 | 0.5 | 43 | 7 | 0 | 0 | 2.4 | 3.6 | 0.9 | 0.002 |
| Berkeley | 2.6 | 10 | 0.3 | 85 | 9 | 0 | 0 | 2.7 | 3.8 | 0.6 | 0.002 |
| Bishop | 1.7 | 10 | 1.2 | 62 | 6 | 0 | 0 | 2.0 | 3.0 | 0.9 | 0.001 |
| Brawley | 2.1 | 9 | 1.4 | 47 | 4 | 0 | 4 | 2.5 | 4.0 | 0.9 | 0.002 |
| Crescent City | 2.4 | 26 | 0.7 | 109 | 15 | 0 | 0 | 3.0 | 4.5 | 1.1 | 0.006 |
| Eureka | 2.2 | 18 | 0.8 | 77 | 13 | 0 | 0 | 2.8 | 4.0 | 1.3 | 0.003 |
| Fresno | 2.7 | 9 | 0.8 | 70 | 13 | 0 | 0 | 2.5 | 4.3 | 0.9 | 0.002 |
| Los Angeles | 2.2 | 6 | 0.7 | 48 | 13 | 0 | 4 | 2.2 | 3.4 | 0.8 | 0.002 |
| Needles | 2.0 | 10 | 0.9 | 48 | 4 | 0 | 3 | 2.1 | 3.1 | 0.8 | 0.008 |
| Quincy | 1.7 | 9 | 0.7 | 55 | 5 | 2 | 0 | 2.1 | 2.7 | 0.8 | 0.001 |
| Redding | 1.8 | 10 | 0.6 | 56 | 31 | 0 | 1 | 1.8 | 4.1 | 0.6 | 0.002 |
| Sacramento | 2.8 | 16 | 0.7 | 84 | 2 | 0 | 0 | 3.0 | 5.6 | 1.2 | 0.001 |
| Salinas | 2.3 | 10 | 0.7 | 61 | 5 | 0 | 0 | 3.0 | 4.8 | 0.8 | 0.002 |
| San Bernardino | 1.5 | 10 | 0.4 | 38 | 2 | 0 | 1 | 1.8 | 2.6 | 0.8 | NA |
| San Diego | 1.7 | 10 | 0.7 | 44 | 2 | 0 | 0 | 2.3 | 2.6 | 0.8 | 0.002 |
| San Luis Obispo | 1.4 | 12 | 0.7 | 35 | 3 | 0 | 6 | 2.2 | 2.3 | 0.8 | 0.001 |
| Santa Barbara | 2.2 | 15 | 0.8 | 61 | 2 | 0 | 0 | 2.6 | 4.0 | 1.0 | 0.006 |
| Santa Rosa | 2.4 | 13 | 0.5 | 68 | 7 | 0 | 0 | 2.3 | 3.0 | 1.3 | NA |
| Susanville | 2.0 | 11 | 0.3 | 80 | 9 | 0 | 3 | 2.3 | 4.7 | 0.7 | 0.001 |
| Ukiah | 2.4 | 15 | 0.4 | 71 | 8 | 3 | 8 | 2.6 | 3.6 | 1.4 | NA |

[a] Based on analyses of hospital standard diets located in listed cities. Strontium-89 was not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] Stable strontium consists of $^{88}Sr$—82.7 percent; $^{87}Sr$—7.0 percent; $^{86}Sr$—9.8 percent; $^{84}Sr$—0.5 percent; total—100 percent.
NA, no analysis performed.

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action.

Average strontium-90 intake in the California diet for the May through June period varied from 7 to 23 pCi/capita/day. Cesium-137 intakes varied from 40 to 106 pCi/capita/day. Radium-226 intakes varied from 0.2 to 1.0 pCi/capita/day.

For the July through August sampling period the strontium-90 average varied from 6 to 26 pCi/capita/day. Cesium-137 intakes varied from 35 to 109 pCi/capita/day. Radium-226 intakes varied from 0.3 to 1.4 pCi/capita/day.

The observed intakes of strontium-90, cesium-137, and radium-226 in California diets were of such a magnitude that no actions were indicated based upon health implications.

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(4) RIVERA, J. Dietary intakes and body burdens of cesium-137. Rad Health Data 6:504–506 (September 1965).

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Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| January–June 1964 | March and April 1965 |
| July–October 1964 | September 1965 |
| November–December 1964 | December 1965 |
| January–April 1965 | March 1966 |

150

# Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Guides may be higher if total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below:

| Program | Period reported | Last presented |
|---|---|---|
| Colorado River Basin Sampling Network | 1962–1964 | November 1965 |
| Coast Guard Water Sampling Program | 1964 | November 1965 |
| Drinking Water Analysis Program | 1962 | October 1965 |
| California Water Sampling Program | January–June 1965 | March 1966 |
| Florida Water Sampling Program | 1964 | November 1965 |
| Kentucky Water Sampling Program | May 1963–June 1964 | March 1965 |
| Minnesota Surface Water Sampling Program | January–June 1965 | February 1966 |
| North Carolina Water Sampling Program | 1964 | November 1965 |
| Lower Columbia River Radiological Survey in Oregon | August 1963–July 1964 | October 1965 |
| Washington Surface Water Sampling Program | July 1964–June 1965 | May 1966 |

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962. Public Health Service Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

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(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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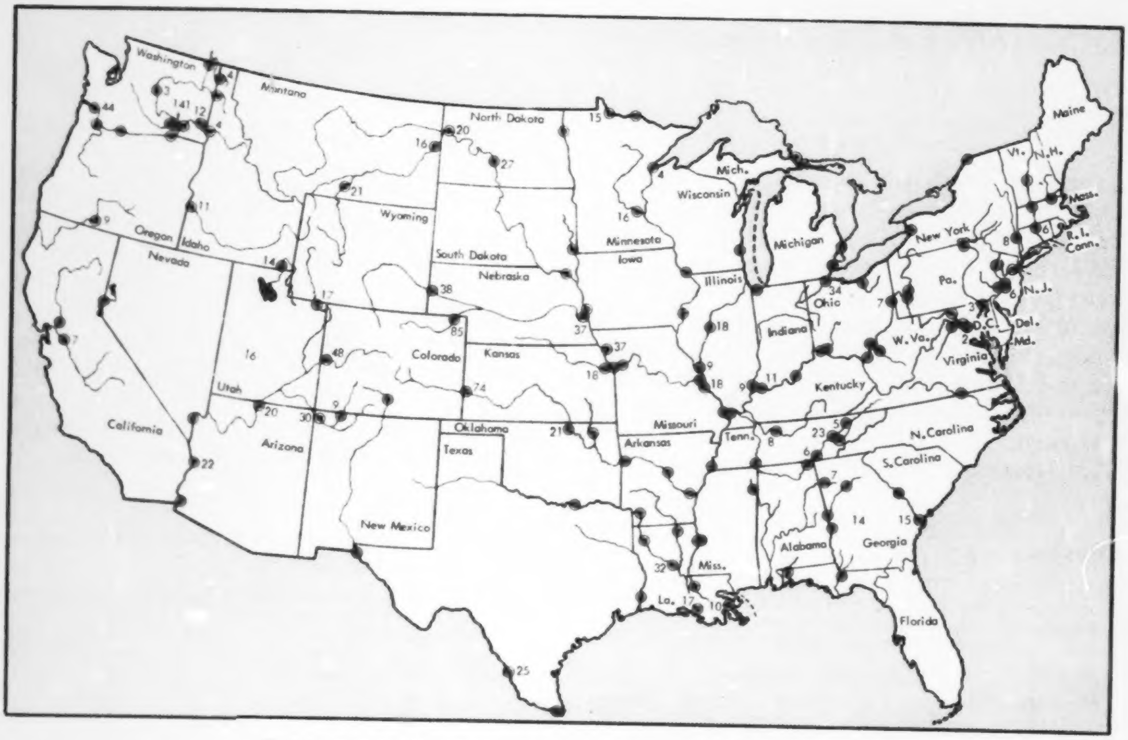
[1] Absence is taken to mean a neglibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

# GROSS RADIOACTIVITY, DECEMBER 1965, AND STRONTIUM-90, APRIL-SEPTEMBER 1965, IN SURFACE WATERS OF THE UNITED STATES

*Basic Data Program, Federal Water Pollution Control Administration*

*Department of the Interior*

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Beginning with the establishment of 50 sampling points, this system has been expanded to include 131 stations. These stations are operated jointly with other Federal, State, and local agencies, and with private industries. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. The system provides background information necessary for recognizing water quality trends and for determining current and general levels of surface water contamination and early detection of specific situations which may warrant more detailed evaluation. Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.


Washington
Montana
North Dakota
Minnesota
Wisconsin
Mich.
Michigan
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
New York
Pa.
N.J.
Del.
Md.
D.C.
Virginia
W. Va.
Ohio
Indiana
Illinois
Iowa
Kentucky
Tenn.
N. Carolina
S. Carolina
Georgia
Alabama
Florida
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Kansas
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South Dakota
Oklahoma
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New Mexico
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Utah
Arizona
Nevada
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6
32
17
10
25

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, December 1965

### *Sampling procedures*

The participating agencies collect 1–liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary. Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short-term increases in radioactivity from current or recent nuclear tests or events.

### *Analytical methods*

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of $U_3O_8$, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Normally, samples are counted within 2 weeks following collection or within 1 week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. If a recount indicates that the original analysis was questionable, values based on the recount are recorded. All results are reported for the time of counting and are not extrapolated to the date of collection.

### *Results*

Table 1 presents the current preliminary results of the alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their distance from the headwaters. The figures for gross alpha and beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as <1 pCi/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations shown in figure 1, which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station.

It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity, whereas fallout contributes primarily additional beta activity. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes (*9*).

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater, or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service Drinking Water Standards have already provided the basis for this assessment (*10*). Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

The following stations showed alpha values on dissolved solids in excess of 15 pCi/liter for

### Table 1. Radioactivity in raw surface waters, December 1965

| Station | Average beta activity (pCi/liter) | | | Average alpha activity (pCi/liter) | | |
| --- | --- | --- | --- | --- | --- | --- |
| | Suspended | Dissolved | Total | Suspended | Dissolved | Total |
| Animas River: | | | | | | |
| Cedar Hill, N. Mex | 4 | 5 | 9 | 1 | 1 | 2 |
| Arkansas River: | | | | | | |
| Coolidge, Kans | 13 | 61 | 74 | 3 | 28 | 31 |
| Ponca City, Okla | 11 | 10 | 21 | 5 | 8 | 13 |
| Atchafalaya River: | | | | | | |
| Morgan City, La | 7 | 10 | 17 | 2 | 2 | 4 |
| Bear River: | | | | | | |
| Preston, Idaho | 2 | 12 | 14 | 0 | 3 | 3 |
| Big Horn River: | | | | | | |
| Hardin, Mont | 1 | 20 | 21 | 0 | 9 | 9 |
| Chena River: | | | | | | |
| Fairbanks, Alaska | 1 | 8 | 9 | 0 | 0 | 0 |
| Clearwater River: | | | | | | |
| Lewiston, Idaho | 1 | 3 | 4 | 0 | <1 | <1 |
| Clinch River: | | | | | | |
| Clinton, Tenn | 0 | 5 | 5 | 0 | 0 | 0 |
| Kingston, Tenn | 5 | 18 | 23 | <1 | <1 | <1 |
| Colorado River: | | | | | | |
| Loma, Colo | 18 | 30 | 48 | 7 | 13 | 20 |
| Page, Ariz | <1 | 20 | 20 | 0 | 4 | 4 |
| Parker Dam, Calif-Ariz | 0 | 22 | 22 | 0 | 9 | 9 |
| Columbia River: | | | | | | |
| Wenatchee, Wash | 0 | 3 | 3 | 0 | 1 | 1 |
| Pasco, Wash | 31 | 110 | 141 | 0 | 1 | 1 |
| Clatskanie, Ore | 5 | 39 | 44 | 0 | 1 | 1 |
| Connecticut River: | | | | | | |
| Enfield Dam, Conn | 0 | 6 | 6 | 0 | 0 | 0 |
| Coosa River: | | | | | | |
| Rome, Ga | 2 | 5 | 7 | 1 | 0 | 1 |
| Cumberland River: | | | | | | |
| Cheatham Lock, Tenn | 0 | 8 | 8 | 0 | 0 | 0 |
| Delaware River: | | | | | | |
| Philadelphia, Pa | 2 | 4 | 6 | 1 | 0 | 1 |
| Great Lakes: | | | | | | |
| Duluth, Minn | 0 | 4 | 4 | 0 | 0 | 0 |
| Green River: | | | | | | |
| Dutch John, Utah | 0 | 17 | 17 | 0 | 3 | 3 |
| Hudson River: | | | | | | |
| Poughkeepsie, N.Y | 1 | 7 | 8 | 0 | 0 | 0 |
| Illinois River: | | | | | | |
| Peoria, Ill | 7 | 11 | 18 | 2 | 3 | 5 |
| Grafton, Ill | 3 | 6 | 9 | 1 | 3 | 4 |
| Kansas River: | | | | | | |
| De Soto, Kans | 1 | 17 | 18 | 0 | 4 | 4 |
| Klamath River: | | | | | | |
| Keno, Ore | 1 | 8 | 9 | 0 | 0 | 0 |
| Maumee River: | | | | | | |
| Toledo, Ohio | 4 | 30 | 34 | 1 | 2 | 3 |
| Mississippi River: | | | | | | |
| St. Paul, Minn | 0 | 16 | 16 | 0 | 2 | 2 |
| E. St. Louis, Ill | 3 | 15 | 18 | 1 | 3 | 4 |
| New Orleans, La | 0 | 10 | 10 | 0 | 1 | 1 |
| Missouri River: | | | | | | |
| Williston, N. Dak | 3 | 17 | 20 | 0 | 5 | 5 |
| Bismarck, N. Dak | 5 | 22 | 27 | 2 | 4 | 6 |
| St. Joseph, Mo | 10 | 27 | 37 | 3 | 7 | 10 |
| North Platte River: | | | | | | |
| Henry, Nebr | 5 | 33 | 38 | 1 | 21 | 22 |
| Ohio River: | | | | | | |
| Toronto, Ohio | 0 | 7 | 7 | 0 | 0 | 0 |
| Cairo, Ill | 1 | 10 | 11 | 0 | 1 | 1 |
| Pend Oreille River: | | | | | | |
| Albeni Falls Dam, Idaho | <1 | 4 | 4 | 0 | 1 | 1 |
| Platte River: | | | | | | |
| Plattsmouth, Nebr | 14 | 23 | 37 | 4 | 8 | 12 |
| Potomac River: | | | | | | |
| Washington, D.C | 0 | 2 | 2 | 0 | 1 | 1 |
| Rainy River | | | | | | |
| Baudette, Minn | 1 | 14 | 15 | 0 | 0 | 0 |
| Red River, South: | | | | | | |
| Alexandria, La | 9 | 23 | 32 | 3 | 1 | 4 |
| Rio Grande: | | | | | | |
| Laredo, Tex | 10 | 15 | 25 | 2 | 5 | 7 |
| San Joaquin River: | | | | | | |
| Vernalis, Calif | 2 | 5 | 7 | 2 | 1 | 3 |
| San Juan River: | | | | | | |
| Shiprock, N. Mex | 22 | 8 | 30 | 7 | 2 | 9 |
| Savannah River: | | | | | | |
| Port Wentworth, Ga | 4 | 11 | 15 | 0 | 0 | 0 |
| Snake River: | | | | | | |
| Payette, Idaho | 1 | 10 | 11 | 0 | 4 | 4 |
| Wawawai, Wash | 1 | 11 | 12 | 0 | 3 | 3 |
| South Platte River: | | | | | | |
| Julesburg, Colo | 17 | 68 | 85 | 4 | 43 | 47 |
| Susquehanna River: | | | | | | |
| Conowingo, Md | 0 | 3 | 3 | 0 | 0 | 0 |
| Tennessee River: | | | | | | |
| Chattanooga, Tenn | 1 | 5 | 6 | 0 | 0 | 0 |
| Wabash River: | | | | | | |
| New Harmony, Ind | 1 | 8 | 9 | 0 | 1 | 1 |
| Yellowstone River: | | | | | | |
| Sidney, Mont | 1 | 15 | 16 | 1 | 4 | 5 |
| Maximum | 31 | 110 | 141 | 7 | 43 | 47 |
| Minimum | 0 | 2 | 2 | 0 | 0 | 0 |

both November and December:

South Platte River: Julesburg, Colorado
North Platte River: Henry, Nebraska
Arkansas River: Coolidge, Kansas

The observed levels of radioactivity are entirely normal for these stations.

Pasco, Washington, showed a decline in dissolved beta radioactivity from about 150 pCi/liter in November to less than 150 pCi/liter in December.

#### *Strontium-90 determinations and results*

Beginning in 1959, strontium-90 analyses of the total solids in surface waters were made quarterly on 3-month composites of aliquots from weekly samples. Beginning in November 1962, the frequency of analysis was reduced to two quarterly samples per year at each sampling point except at those stations immediately below nuclear installations, where regular quarterly analyses were continued. The method used for determining strontium-90 is a modification of a procedure described by Harley (8). Yttrium-90, together with an yttrium carrier, is precipitated as yttrium oxalate. The latter is washed, dried, weighed, and counted in a low-background, anticoincidence, end-window proportional counter as a measure of the strontium-90 activity.

Table 2 presents the results of quarterly analyses of strontium-90 concentrations in U.S. surface waters for the second and third quarters of 1965. The stations are arranged in the table according to their distance from the headwaters.

**Table 2. Quarterly strontium-90 concentrations in surface waters, April–September 1965**

| Station | Average concentration (pCi/liter) | |
|---|---|---|
| | Apr–June 1965 | July–Sept 1965 |
| Allegheny River: | | |
| Pittsburgh, Pa | 1.1 | |
| Animas River: | | |
| Cedar Hill, N. Mex | | 1.5 |
| Apalachicola River: | | |
| Chattahoochee, Fla | | 0.4 |
| Arkansas River: | | |
| Coolidge, Kans | | 3.3 |
| Ponca City, Okla | 2.2 | |
| Fort Smith, Ark | | 2.9 |
| Little Rock, Ark | 2.0 | |
| Pendleton Ferry, Ark | 2.3 | |
| Atchafalaya River: | | |
| Morgan City, La | | 2.4 |
| Bear River: | | |
| Preston, Idaho | | 0.4 |
| Big Horn River: | | |
| Hardin, Mont | 1.8 | |
| Big Sioux River: | | |
| Sioux Falls, S. Dak | | 2.5 |
| Chattahoochee River: | | |
| Atlanta, Ga | 0.7 | |
| Lanett, Ala | | 0.8 |
| Columbus, Ga | 1.1 | |
| Chena River: | | |
| Fairbanks, Alaska | 0.4 | |
| Clearwater River: | | |
| Lewiston, Idaho | | 0.4 |
| Clinch River: | | |
| Clinton, Tenn | | 0.4 |
| Kingston, Tenn | 1.6 | 1.3 |
| Colorado River: | | |
| Loma, Colo | 1.9 | |
| Page, Ariz | | 0.7 |
| Boulder City, Nev | 1.9 | |
| Parker Dam, Calif-Ariz | | 2.0 |
| Yuma, Ariz | 0.5 | |
| Columbia River: | | |
| Northport, Wash | | 0.9 |
| Wenatchee, Wash | 0.8 | |
| Pasco, Wash | 0.9 | 1.0 |
| McNary Dam, Ore | 0.7 | 0.8 |
| Bonneville, Ore | | 0.5 |
| Clatskanie, Ore | 0.6 | |
| Connecticut River: | | |
| Wilder, Vt | | 0.5 |
| Northfield, Mass | 1.1 | |
| Enfield Dam, Conn | | 1.0 |
| Coosa River: | | |
| Rome, Ga | | 0.1 |
| Cumberland River: | | |
| Cheatham Lock, Tenn | | 0.8 |
| Cuyahoga River: | | |
| Cleveland, Ohio | | 2.2 |
| Delaware River: | | |
| Martins Creek, Pa | 0.6 | |
| Trenton, N.J | | 0.7 |
| Philadelphia, Pa | 1.1 | |
| Escambia River: | | |
| Century, Fla | 0.8 | |
| Great Lakes: | | |
| Duluth, Minn | 0.7 | |
| Sault Ste. Marie, Mich | | 0.4 |
| Milwaukee, Wis | 0.6 | |
| Gary, Ind | | 0.7 |
| Port Huron, Mich | 1.0 | |
| Detroit, Mich | | 1.2 |
| Buffalo, N.Y | 2.0 | |
| Green River: | | |
| Dutch John, Utah | | 1.6 |
| Hudson River: | | |
| Poughkeepsie, N.Y | 1.1 | |
| Illinois River: | | |
| Peoria, Ill | 1.6 | |
| Kanawha River: | | |
| Winfield Dam, W. Va | | 0.3 |
| Kansas River: | | |
| De Soto, Kans | 1.9 | |
| Klamath River: | | |
| Keno, Ore | 1.7 | |
| Little Miami River: | | |
| Cincinnati, Ohio | | 1.1 |
| Maumee River: | | |
| Toledo, Ohio | 1.7 | |
| Merrimack River: | | |
| Lowell, Mass | | 0.7 |
| Mississippi River: | | |
| St. Paul, Minn | | 3.6 |
| Dubuque, Iowa | 4.0 | |
| Burlington, Iowa | | 2.9 |
| E. St. Louis, Ill | 2.7 | |
| Cape Girardeau, Mo | | 2.1 |
| W. Memphis, Ark | 2.3 | |
| Vicksburg, Miss | | 1.7 |
| Delta, La | 2.2 | |
| New Roads, La | 2.3 | |
| New Orleans, La | | 1.8 |
| Missouri River: | | |
| Williston, N. Dak | 1.6 | |
| Bismarck, N. Dak | | 2.1 |
| Yankton, S. Dak | 3.0 | |
| Omaha, Nebr | | 2.5 |
| St. Joseph, Mo | 3.0 | |
| Kansas City, Mo | | 2.6 |
| Missouri City, Mo | 1.9 | |
| St. Louis, Mo | | 2.7 |
| Monongahela River: | | |
| Pittsburgh, Pa | 0.9 | |
| North Platte River: | | |
| Henry, Nebr | 2.2 | |
| Ohio River: | | |
| Toronto, Ohio | 0.8 | |
| Addison, Ohio | | 1.3 |
| Huntington, W. Va | 1.8 | |
| Cincinnati, Ohio | | 1.1 |
| Louisville, Ky | 1.0 | |
| Evansville, Ind | | 0.8 |
| Cairo, Ill | 1.4 | |
| Ouachita River: | | |
| Bastrop, La | | 1.3 |
| Pend Oreille River: | | |
| Albeni Falls Dam, Idaho | 0.4 | |
| Platte River: | | |
| Plattsmouth, Nebr | | 2.9 |
| Potomac River: | | |
| Williamsport, Md | 0.5 | |
| Great Falls, Md | | 0.8 |
| Washington, D.C | | 0.8 |
| Rainy River: | | |
| International Falls, Minn | 3.9 | |
| Baudette, Minn | 2.8 | |
| Red River, North: | | |
| Grand Forks, N. Dak | 6.1 | 5.2 |
| Red River, South: | | |
| Denison, Tex | 3.7 | 4.1 |
| Index, Ark | 3.1 | |
| Bossier City, La | | 1.3 |
| Alexandria, La | 2.0 | |
| Rio Grande: | | |
| Alamosa, Colo | 1.2 | |
| El Paso, Tex | | 1.0 |
| Laredo, Tex | 1.4 | |
| Brownsville, Tex | | 1.3 |
| Roanoke River: | | |
| John H. Kerr Resr. & Dam, Va | 1.1 | |
| Sabine River: | | |
| Ruliff, Tex | | 1.9 |
| Sacramento River: | | |
| Greens Landing, Calif | | 0.1 |
| St. Lawrence River: | | |
| Massena, N.Y | | 1.0 |
| San Joaquin River: | | |
| Vernalis, Calif | 0.8 | |
| San Juan River: | | |
| Shiprock, N. Mex | 2.0 | |
| Savannah River: | | |
| North Augusta, S.C | | 0.4 |
| Port Wentworth, Ga | 1.6 | 1.2 |
| Schuylkill River: | | |
| Philadelphia, Pa | | 0.9 |
| Shenandoah River: | | |
| Berryville, Va | 0.6 | |
| Ship Creek: | | |
| Anchorage, Alaska | | 0.1 |
| Snake River: | | |
| Payette, Idaho | 0.7 | |
| Wawawai, Wash | 0.4 | |
| Ice Harbor Dam, Wash | | 0.1 |
| South Platte River: | | |
| Julesburg, Colo | 1.8 | |
| Spokane River: | | |
| Post Falls Dam, Idaho | | 0.3 |
| Susquehanna River: | | |
| Sayre, Pa | | 0.4 |
| Conowingo, Md | 1.0 | |
| Tennessee River: | | |
| Lenoir City, Tenn | 0.6 | |
| Chattanooga, Tenn | 1.0 | 0.6 |
| Bridgeport, Ala | 1.0 | |
| Pickwick Landing, Tenn | | 0.7 |
| Tombigbee River: | | |
| Columbus, Miss | | 0.6 |
| Truckee River: | | |
| Farad, Calif | 0.6 | |
| Verdigris River: | | |
| Nowata, Okla | 2.7 | |
| Wabash River: | | |
| New Harmony, Ind | 1.2 | |
| Willamette River: | | |
| Portland, Ore | 0.2 | |
| Yakima River: | | |
| Richland, Wash | | 0.1 |
| Yellowstone River: | | |
| Sidney, Mont | | 1.5 |
| Maximum | 6.1 | 5.2 |
| Minimum | 0.2 | 0.1 |

While there are no standards for strontium-90 activity of total solids in surface waters, the Public Health Service Drinking Water Standards set the limit for approval of a drinking water supply containing strontium-90 at 10 pCi/liter. During the second and third quarters of 1965, this concentration was not reached in raw surface waters. Comparison between the two quarters is not feasible at all sampling locations due to fluctuations in sampling frequencies. Comparison with results prior to October 1964 should take into consideration an instrument recalibration which resulted in a lowering of strontium-90 values by 15 percent (*11*).

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# RADIOACTIVITY IN NEW YORK SURFACE WATER JUNE–DECEMBER 1965

*Division of Environmental Health Service, State of New York Department of Health*

The New York Department of Health began a program in 1955 to determine the amount of radioactivity in water used for public consumption. This radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations. Water samples are obtained from 45 locations for gross beta analysis (figure 1). Table 1 gives the sampling frequency and type of sample. Larger size samples are collected at selected locations for strontium–90 analysis.

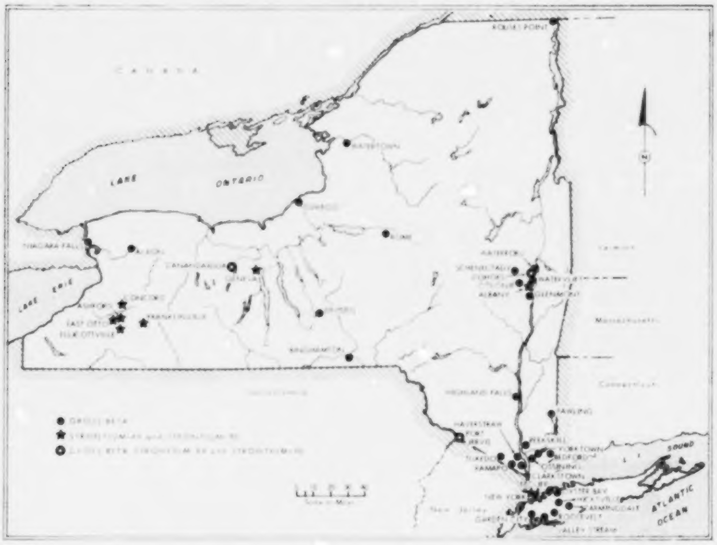
### *Analytical procedures*

Beta activity concentrations are determined by evaporating a known volume of water to dryness and counting in an end-window, gas-flow proportional counter.

For strontium–89 and strontium–90 determinations, a measured volume of water is passed through an ion exchange column. The strontium is then eluted from the resin, concentrated, and counted in a low background, end-window, gas-flow proportional counter. Successive countings at 2-day intervals facilitate the determination of the strontium–90 and strontium–89 concentrations.

### *Discussion and results*

The observed gross beta activity concentrations in New York surface water for June-December 1965 are given in table 1. It should be noted that the Cohoes gross beta results are for a raw water sample, while the Cohoes radiostrontium results are for a finished water.



ROUSES POINT
C A N A D A
WATERTOWN
LAKE ONTARIO
OSWEGO
ROME
NIAGARA FALLS
ALBION
CANANDAIGUA
GENEVA
LAKE ERIE
CONCORD
ASHFORD
EAST OTTO
ELLICOTTVILLE
FRANKLINVILLE
BINGHAMTON
WATERFORD
SCHENECTADY
COHOES
WATERVLIET
ALBANY
Vermont
Massachusetts
Connecticut
HIGHLAND FALLS
PAWLING
HAVERSTRAW
PORT JERVIS
PEEKSKILL
YORKTOWN
BEDFORD
TUXEDO
RAMAPO
OSSINING
CLARKSTOWN
NEW YORK
OYSTER BAY
HICKSVILLE
FARMINGDALE
ROOSEVELT
GARDEN CITY
VALLEY STREAM
New Jersey
SOUND
ATLANTIC OCEAN
N
● GROSS BETA

Figure 1. New York water sampling locations

### Table 1. Gross beta activity concentrations in New York raw surface water June–December 1965

| Location | Sampling frequency | Concentration, pCi/liter | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | June | July | Aug | Sept | Oct | Nov | Dec |
| Akron (Murder Creek) | BD | 8 | 9 | 8 | 7 | 7 | 7 | 9 |
| Bedford (Byram Lake) | M | 10 | 7 | 6 | 7 | 7 | | 9 |
| Binghamton (Binghamton Water Supply) | Q | 4 | | | | | | |
| Canandaigua (Canandaigua Lake) | SA | 5 | | | | | | |
| Clarkstown (Congers Lake) | Q | 13 | | 16 | | | | 9 |
| (Lake De Forest) | Q | 7 | | 7 | | | | 6 |
| Cohoes (Mohawk River) | D | 6 | 7 | 7 | 6 | 7 | 6 | 4 |
| Colonie (Patroon Creek) | SA | | | 6 | | | | |
| Concord (18 Mile Creek) | SA | | | 150 | | | | |
| Dryden (Cayuga Lake) | SA | | | | | | | 1 |
| Farmingdale (Well No. 1) | SA | 2 | | | | | | |
| Garden City (Well No. 2) | SA | 3 | | | | | | |
| Glenmont (Hudson River) | D | 8 | 6 | 6 | 6 | 5 | 5 | 4 |
| Haverstraw (Letchworth Village Reservoix) | Q | 3 | | 3 | | | | 2 |
| Hicksville (Well No. 4) | SA | 2 | | | | | | |
| Highland Falls (Bog Meadow Brook) | M | 4 | 8 | 3 | 4 | 4 | 3 | 3 |
| Lansing (Airport Well) | SA | <1 | | | | | | 2 |
| (East Stream-Cayuga Lake) | SA | 6 | | | | | | 14 |
| (West Stream-Cayuga Lake) | SA | 3 | | | | | | 3 |
| (Kahrs Well) | SA | 2 | | | | | | |
| (Neigh Well) | SA | 1 | | | | | | 3 |
| (Research Park Well) | SA | 2 | | | | | | 2 |
| (Shively Well) | SA | <1 | | | | | | 2 |
| Niagara Falls (East Branch-Niagara River) | M | 8 | 9 | 7 | | | | |
| (West Branch-Niagara River) | M | 7 | 8 | 8 | | | | |
| Ossining (Hudson River) | D | 41 | 53 | 41 | 57 | 41 | 25 | 15 |
| (Indian Brook Reservoir) | M | 8 | 6 | 8 | 7 | 6 | | 6 |
| Oswego (Lake Ontario) | M | 6 | 4 | 4 | 3 | 5 | 4 | 4 |
| Oyster Bay (Lake Ontario) | SA | 2 | | | | | | |
| Pawling (Pond at United Nuclear) | M | 6 | 5 | 5 | | | | |
| Peekskill (Camp Field Water Supply) | M | 4 | 3 | 7 | 13 | 2 | | 22 |
| (Hudson River) | D | 25 | 35 | 35 | 52 | 36 | | 23 |
| Port Jervis (Delaware River) | Q | 4 | | | 3 | | | |
| Ramapo (Hillburn Reservoir) | Q | 3 | | 4 | | | | 1 |
| Rome (Fish Creek) | BD | 5 | 5 | 5 | 4 | 5 | 4 | 4 |
| Roosevelt | SA | 9 | | | | | | |
| Rouses Point (Lake Champlain) | Q | | 5 | | | | | |
| Schenectady (Mohawk River) | C | 4 | 5 | 5 | 5 | 5 | 4 | 5 |
| Sea Cliff (Mohawk River) | SA | 4 | | | | | | |
| Tuxedo (Indian Kill) | M | 5 | 24 | 5 | 9 | 4 | 4 | 4 |
| Valley Stream | SA | 1 | | | | | | |
| Waterford (Hudson Riv[illegible] | C | 6 | 6 | 5 | 5 | 4 | 4 | 3 |
| Watertown (Black River) | BD | 6 | 7 | 5 | 5 | 7 | 6 | 4 |
| Watervliet (French Mills Reservoir) | BD | 5 | | 3 | 4 | 4 | 5 | 5 |
| Yorktown (Croton Reservoir) | M | 7 | 6 | 5 | 4 | 3 | | 3 |

BD, bi-weekly composite of daily grab samples
D, weekly composite of daily grab sample
C, continuous bleed-off, analyzed weekly
M, monthly grab sample
Q, quarterly grab sample
SA, semiannual grab sample

The average concentrations of strontium-89 and strontium-90 for June through August 1965 were less than the level of detectability (3 pCi/liter) except for one strontium-90 result of 6 pCi/liter in July at Jerome Park Reservoir in New York City. Strontium-89 and strontium-90 reports were discontinued at the end of August.

Previous coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| July 1963–June 1964 | December 1964 |
| June 1964–December 1964 | September 1965 |
| January–June 1965 | January 1966 |

# RADIOSTRONTIUM IN TAP WATER MAY AND JULY-NOVEMBER 1965[1]

*Health and Safety Laboratory, U.S. Atomic Energy Commission*

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Cesium-137 to strontium-90 ratios and strontium-90 concentrations in New York City tap water for May and July through November 1965 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentra-

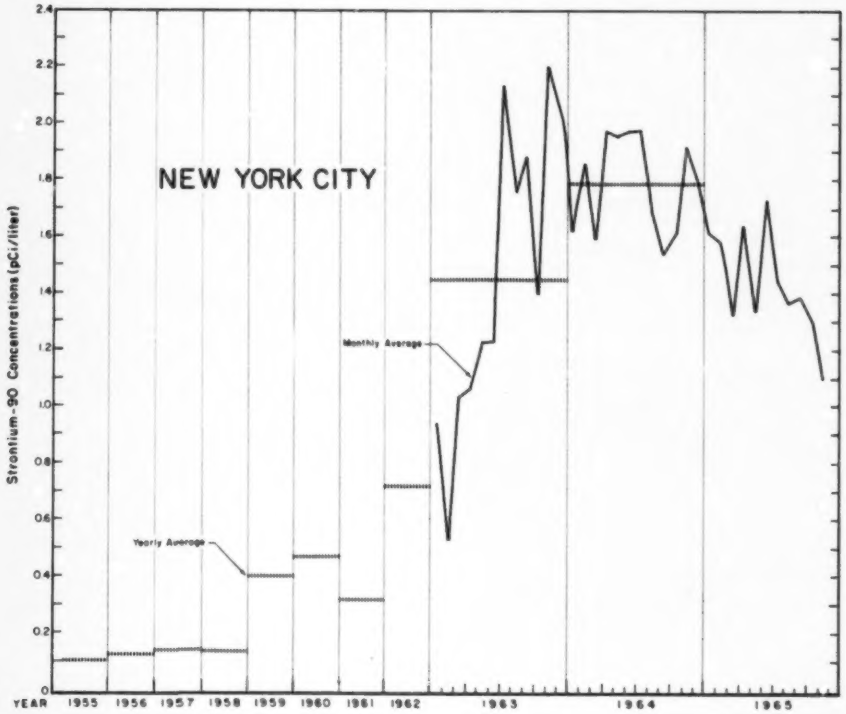


Figure 1. Strontium-90 concentrations in New York City tap water

tions observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

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[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL-171. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 528S Port Royal Road, Springfield, Virginia 22131.

**Table 1. Radiostrontium in New York City tap water May and July–November 1965**

| Month 1965 | New York City | |
|---|---|---|
| | Strontium-90 [a] (pCi/liter) | Cesium-137/ strontium-90 |
| May | 1.34 | 0.18 |
| July | 1.44 | 0.19 |
| August | 1.36 | 0.15 |
| September | 1.38 | 0.12 |
| October | 1.30 | NR |
| November | 1.10 | NR |

[a] Approximately 100 liters per sample
NR, no ratio reported

Previous coverage in *Radiological Health Data:*

| Period | Issue |
|---|---|
| January–April 1962 | September 1962 |
| March–June 1962 | January 1963 |
| July-December 1962 | July 1963 |
| January–April 1963 | January 1964 |
| May–October 1963 | April 1964 |
| November 1963–December 1964 | June 1965 |
| January–June 1965 | December 1965 |

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(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures, 40:E-38-01-16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, New York.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42–Public Health, Chapter 1–Public Health Service. Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards, 27:2154–2155. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

# Section III. Air and Deposition

## RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

| Network | Period reported | Last presented |
|---|---|---|
| Mexican Air Monitoring Program | November 1965 | March 1966 |
| National Air Sampling Network | October-December and Annual Summary 1965 | April 1966 |
| HASL Fallout Network | January-June 1965 | May 1966 |

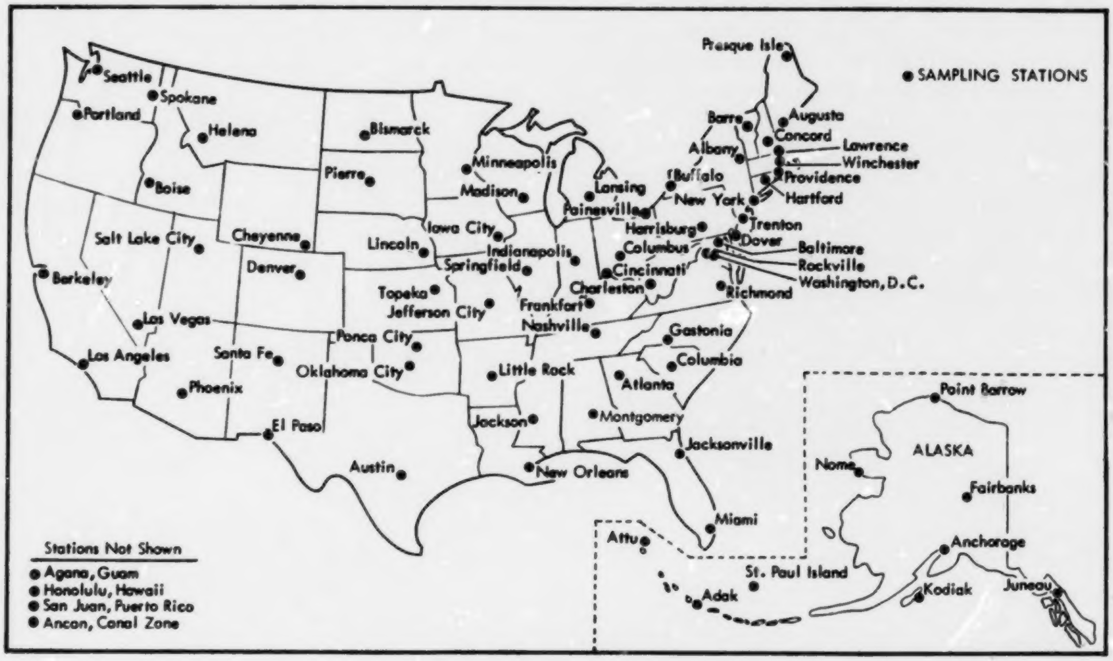
## 1. Radiation Surveillance Network February 1966

*Division of Radiological Health*
*Public Health Service*

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data*.

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during February 1966. Time profiles of gross beta in air dating from 1960 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 227 air samples. Traces of longer-lived fission products were identified in these samples.



● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Berkeley
Salt Lake City
Las Vegas
Los Angeles
Phoenix
Santa Fe
El Paso
Cheyenne
Denver
Bismarck
Pierre
Lincoln
Topeka
Jefferson City
Ponca City
Oklahoma City
Austin
Minneapolis
Madison
Iowa City
Springfield
Indianapolis
Little Rock
Jackson
New Orleans
Lansing
Painesville
Columbus
Cincinnati
Charleston
Frankfort
Nashville
Atlanta
Montgomery
Gastonia
Columbia
Jacksonville
Miami
Presque Isle
Barre
Augusta
Concord
Albany
Buffalo
Lawrence
Winchester
Providence
Hartford
New York
Harrisburg
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Kodiak
Juneau
Attu
Adak
St. Paul Island
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

## Table 1. Gross beta activity in surface air and precipitation, February 1966

| Station location | | Air surveillance | | | | | | Precipitation | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number of samples | | Gross beta activity, pCi/m³ | | | Last profile in *RHD & R* | Total depth (mm) | Total deposition (nCi/m²)[a] |
| | | Air | Pptn | Maximum | Minimum | Average [a] | | | |
| Ala: | Montgomery | 28 | 8 | 0.14 | <0.10 | <0.11 | Feb 66 | 215 | <43 |
| Alaska: | Adak | 28 | NS | 0.11 | <0.10 | <0.10 | Jun 66 | | |
| | Anchorage | 18 | 3 | 0.17 | <0.10 | <0.11 | Mar 66 | 6 | <1 |
| | Attu Island | NS | NS | | | | Oct 65 | | |
| | Fairbanks | 11 | 3 | <0.10 | <0.10 | <0.10 | Apr 66 | 26 | <5 |
| | Juneau | 17 | 13 | <0.10 | <0.10 | <0.10 | May 66 | 137 | <28 |
| | Kodiak | 10 | NS | 0.13 | <0.10 | <0.10 | May 66 | | |
| | Nome | NS | NS | | | | Dec 65 | | |
| | Point Barrow | 25 | NS | 0.13 | <0.10 | <0.10 | Nov 65 | | |
| | St. Paul Island | 26 | NS | <0.10 | <0.10 | <0.10 | Jan 66 | | |
| Ariz: | Phoenix | 27 | NS | 0.19 | <0.10 | <0.12 | May 66 | | |
| Ark: | Little Rock | 21 | 1 | 0.11 | <0.10 | <0.10 | Mar 66 | 50 | <10 |
| Calif: | Berkeley | 19 | 7 | 0.20 | <0.10 | <0.11 | May 66 | 82 | <17 |
| | Los Angeles | 19 | 2 | 0.15 | <0.10 | <0.11 | Dec 65 | 37 | <7 |
| C. Z: | Ancon | 14 | NS | <0.10 | <0.10 | <0.10 | May 66 | | |
| Colo: | Denver | 24 | 3 | 0.17 | <0.10 | <0.11 | May 66 | 17 | <4 |
| Conn: | Hartford | 27 | 9 | 0.11 | <0.10 | <0.10 | Apr 66 | 66 | <13 |
| Del: | Dover | 18 | NS | 0.11 | <0.10 | <0.10 | Feb 66 | | |
| D. C: | Washington | 28 | 8 | 0.11 | <0.10 | <0.10 | Nov 65 | 59 | <12 |
| Fla: | Jacksonville | 26 | 10 | 0.13 | <0.10 | <0.10 | Mar 66 | 154 | <31 |
| | Miami | 27 | 3 | 0.13 | <0.10 | <0.10 | Apr 66 | 103 | <21 |
| Ga: | Atlanta | NS | NS | | | | Jan 66 | | |
| Guam: | Agana | 26 | NS | <0.10 | <0.10 | <0.10 | Feb 66 | | |
| Hawaii: | Honolulu | 28 | 5 | <0.10 | <0.10 | <0.10 | Oct 65 | 113 | <23 |
| Idaho: | Boise | 23 | 2 | 0.53 | <0.10 | <0.12 | Oct 65 | 39 | <6 |
| Ill: | Springfield | 24 | 1 | 0.16 | <0.10 | <0.11 | Nov 65 | 70 | <14 |
| Ind: | Indianapolis | 28 | 7 | 0.16 | <0.10 | <0.10 | Jan 66 | 70 | <14 |
| Iowa: | Iowa City | 26 | 3 | 0.18 | <0.10 | <0.10 | Jun 66 | 18 | <4 |
| Kans: | Topeka | 28 | 2 | 0.16 | <0.10 | <0.10 | Mar 66 | 13 | <3 |
| Ky: | Frankfort | 26 | 6 | 0.12 | <0.10 | <0.10 | Nov 65 | 35 | <7 |
| La: | New Orleans | 27 | 11 | 0.13 | <0.10 | <0.10 | Nov 65 | 255 | <51 |
| Maine: | Augusta | 26 | 5 | <0.10 | <0.10 | <0.10 | Dec 65 | 119 | <24 |
| | Presque Isle | 24 | NS | <0.10 | <0.10 | <0.10 | Jun 66 | | |
| Md: | Baltimore | 17 | 5 | 0.12 | <0.10 | <0.16 | Apr 66 | 50 | <10 |
| | Rockville | 15 | NS | 0.11 | <0.10 | <0.10 | Oct 65 | | |
| Mass: | Lawrence | 28 | 6 | 0.16 | <0.10 | <0.11 | Feb 66 | 48 | <10 |
| | Winchester | 27 | 7 | <0.10 | <0.10 | <0.10 | Sep 65 | 39 | <8 |
| Mich: | Lansing | 28 | | 0.12 | <0.10 | <0.10 | Oct 65 | | |
| Minn: | Minneapolis | 18 | 5 | <0.10 | <0.10 | <0.10 | Feb 66 | 41 | <8 |
| Miss: | Jackson | 24 | 6 | 0.12 | <0.10 | <0.10 | Dec 65 | 145 | <29 |
| Mo: | Jefferson City | 28 | 6 | 0.11 | <0.10 | <0.10 | Jan 66 | 64 | <13 |
| Mont: | Helena | 27 | 4 | 0.19 | <0.10 | <0.11 | Jun 66 | 10 | <2 |
| Nebr: | Lincoln | 15 | NS | 0.11 | <0.10 | <0.10 | Jan 66 | | |
| Nev: | Las Vegas | 26 | NS | 0.19 | <0.10 | <0.12 | Apr 66 | | |
| N. H: | Concord | 19 | NS | 0.13 | <0.10 | <0.10 | Nov 65 | | |
| N. J: | Trenton | 27 | 6 | 0.14 | <0.10 | <0.10 | Dec 65 | 23 | <5 |
| N. Mex: | Santa Fe | 28 | 6 | 0.17 | <0.10 | <0.11 | Jun 66 | 14 | <3 |
| N. Y: | Albany | 19 | 7 | 0.13 | <0.10 | <0.10 | Jan 66 | 53 | <11 |
| | Buffalo | 26 | NS | 0.17 | <0.10 | <0.10 | Jun 66 | | |
| | New York | 27 | NS | <0.10 | <0.10 | <0.10 | Sep 65 | | |
| N. C: | Gastonia | 28 | 8 | 0.12 | <0.10 | <0.10 | Jun 66 | 110 | <22 |
| N. Dak: | Bismarck | 27 | 2 | <0.10 | <0.10 | <0.10 | Nov 65 | 7 | <1 |
| Ohio: | Cincinnati | 18 | NS | <0.10 | <0.10 | <0.10 | Feb 66 | | |
| | Columbus | 28 | 5 | 0.22 | <0.10 | <0.12 | Dec 65 | 41 | <8 |
| | Painesville | 28 | 6 | 0.13 | <0.10 | <0.10 | Apr 66 | 38 | <8 |
| Okla: | Oklahoma City | 27 | 4 | <0.10 | <0.10 | <0.10 | Oct 65 | 34 | <7 |
| | Ponca City | 25 | 4 | <0.10 | <0.10 | <0.10 | Apr 66 | 44 | <9 |
| Ore: | Portland | 28 | 11 | 0.16 | <0.10 | <0.11 | Jan 66 | 43 | <9 |
| Pa: | Harrisburg | 26 | 3 | <0.10 | <0.10 | <0.10 | Jan 66 | 47 | <10 |
| P. R: | San Juan | 23 | 1 | 0.25 | <0.10 | <0.11 | Dec 65 | 15 | <3 |
| R. I: | Providence | 27 | 5 | <0.10 | <0.10 | <0.10 | Oct 65 | 63 | <13 |
| S. C: | Columbia | 24 | 6 | 0.12 | <0.10 | <0.10 | Sep 65 | 77 | <15 |
| S. Dak: | Pierre | 26 | 1 | <0.10 | <0.10 | <0.10 | May 66 | 13 | 2 |
| Tenn: | Nashville | 27 | 9 | <0.10 | <0.10 | <0.10 | Oct 65 | 95 | <19 |
| Tex: | Austin | 28 | 7 | 0.17 | <0.10 | <0.11 | Feb 66 | 65 | <13 |
| | El Paso | 27 | 2 | 0.19 | <0.10 | <0.12 | Nov 65 | 9 | <2 |
| Utah: | Salt Lake City | 26 | 7 | 0.15 | <0.10 | <0.11 | Dec 65 | 41 | <8 |
| Vt: | Barre | 27 | 6 | 0.11 | <0.10 | <0.10 | Mar 66 | 49 | <10 |
| Va: | Richmond | 28 | 7 | 0.12 | <0.10 | <0.10 | Mar 66 | 74 | <15 |
| Wash: | Seattle | 28 | 14 | <0.10 | <0.10 | <0.10 | Mar 66 | 43 | <9 |
| | Spokane | 27 | 2 | <0.10 | <0.10 | <0.10 | Feb 66 | 7 | <1 |
| W. Va: | Charleston | 26 | 9 | <0.10 | <0.10 | <0.10 | Sep 65 | 57 | <11 |
| Wis: | Madison | 27 | 4 | <0.10 | <0.10 | <0.10 | Mar 66 | 28 | <6 |
| Wyo: | Cheyenne | 28 | 2 | 0.16 | <0.10 | <0.11 | Apr 66 | 5 | <1 |
| Network summary | | 1,732 | 295 | 0.53 | <0.10 | <0.10 | | 59 | <12 |

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

NS, no air or precipitation sample collected.

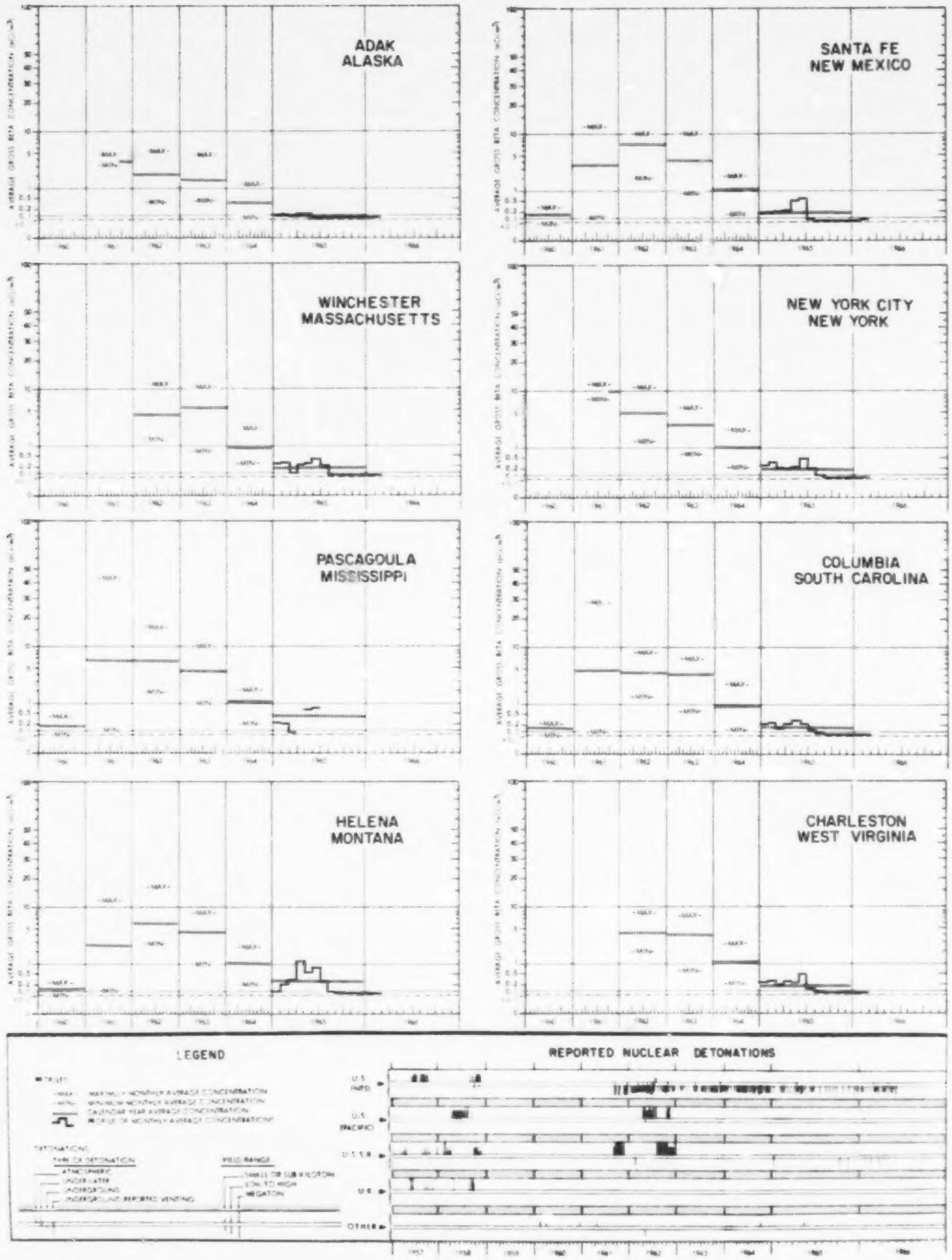


Figure 2. Monthly and yearly profiles of beta activity in air
Radiation Surveillance Network, 1960–February 1966

## 2. Canadian Air and Precipitation Monitoring Program, February 1966[1]

*Radiation Protection Division, Department of National Health and Welfare*
*Ottawa, Canada*

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data*.

Surface air and precipitation data for February 1966 are presented in table 2.

**Table 2. Canadian gross beta activity in surface air and precipitation, February 1966**

| Station | Air surveillance | | | | Precipitation measurements | |
|---|---|---|---|---|---|---|
| | Number of samples | Activity, pCi/m³ | | | Average concentration (pCi/liter) | Total deposition (nCi/m²) |
| | | Maximum | Minimum | Average | | |
| Calgary | 28 | 0.2 | 0.0 | 0.1 | 177 | 0.9 |
| Coral Harbour | 28 | 0.2 | 0.0 | 0.1 | 28 | 0.5 |
| Edmonton | 28 | 0.2 | 0.0 | 0.1 | 47 | 0.5 |
| Ft. Churchill | 28 | 0.1 | 0.0 | 0.1 | 39 | 0.5 |
| Ft. William | 27 | 0.2 | 0.1 | 0.1 | 50 | 0.7 |
| Fredericton | 27 | 0.1 | 0.0 | 0.1 | 16 | 1.2 |
| Goose Bay | 27 | 0.2 | 0.0 | 0.1 | 13 | 0.4 |
| Halifax | 28 | 0.1 | 0.0 | 0.1 | 41 | 2.1 |
| Inuvik | 28 | 0.2 | 0.1 | 0.1 | 41 | 0.4 |
| Montreal | 28 | 0.2 | 0.0 | 0.1 | 21 | 1.3 |
| Moosonee | 28 | 0.1 | 0.0 | 0.1 | 18 | 0.7 |
| Ottawa | 28 | 0.1 | 0.0 | 0.1 | 23 | 0.7 |
| Quebec | 27 | 0.1 | 0.0 | 0.1 | 47 | 2.1 |
| Regina | 28 | 0.2 | 0.1 | 0.1 | 38 | 0.3 |
| Resolute | 28 | 0.2 | 0.0 | 0.1 | NS | NS |
| St. John's, Nfld | 28 | 0.1 | 0.0 | 0.1 | 17 | 1.1 |
| Saskatoon | 28 | 0.2 | 0.0 | 0.1 | 37 | 0.4 |
| Sault Ste. Marie | 28 | 0.1 | 0.0 | 0.1 | 24 | 1.4 |
| Toronto | 28 | 0.1 | 0.0 | 0.1 | 25 | 1.1 |
| Vancouver | 28 | 0.1 | 0.0 | 0.0 | 41 | 2.0 |
| Whitehorse | 28 | 0.2 | 0.0 | 0.1 | 20 | 0.4 |
| Windsor | 28 | 0.2 | 0.0 | 0.1 | 21 | 0.9 |
| Winnipeg | 28 | 0.2 | 0.1 | 0.1 | 97 | 1.0 |
| Yellowknife | 28 | 0.2 | 0.1 | 0.1 | T | 0.4 |
| Network summary | | 0.2 | 0.0 | 0.1 | 40 | 0.9 |

NS, no sample collected.
T, trace amount observed, below quantifiable level.

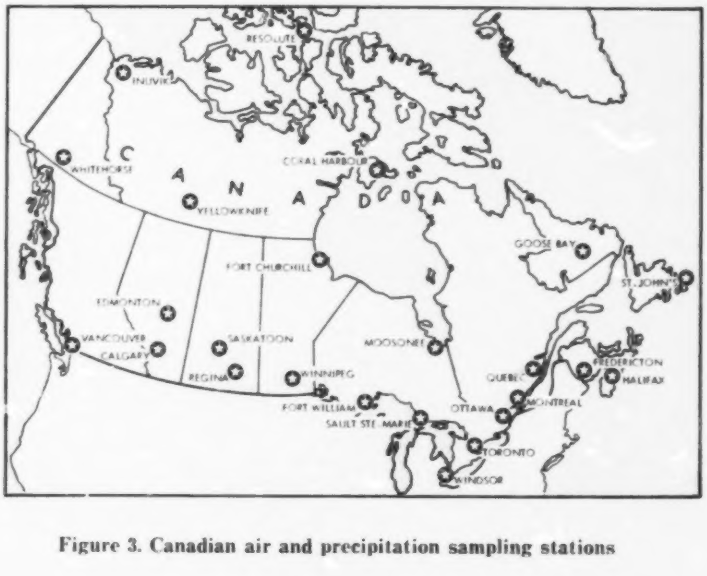

RESOLUTE
INUVIK
WHITEHORSE
C
A
N
A
D
A
COR AL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
SAULT STE. MARIE
OTTAWA
MONTREAL
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the October 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

## 3. Pan American Air Sampling Program February 1966

*Pan American Health Organization*
*and U.S. Public Health Service*

Gross beta activity in air is monitored by countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The locations of air sampling stations are shown in figure 4.

The February 1966 air monitoring results from the participating countries are given in table 3.

**Table 3. PAHO gross beta activity in surface air and precipitation, February 1966**

| Station location | Number of samples | Gross beta activity, pCi/m³ | | |
|---|---|---|---|---|
| | | Maximum | Minimum | Average [a] |
| Argentina: Buenos Aires | 15 | <0.10 | <0.10 | <0.10 |
| Chile: Santiago | 21 | <0.10 | <0.10 | <0.10 |
| Jamaica: Kingston | 21 | <0.10 | <0.10 | <0.10 |
| Peru: Lima | 22 | <0.10 | <0.10 | <0.10 |
| Venezuela: Caracas | 17 | <0.10 | <0.10 | <0.10 |
| West Indies: Trinidad | 16 | <0.10 | <0.10 | <0.10 |
| Pan American summary | 112 | <0.10 | <0.10 | <0.10 |

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

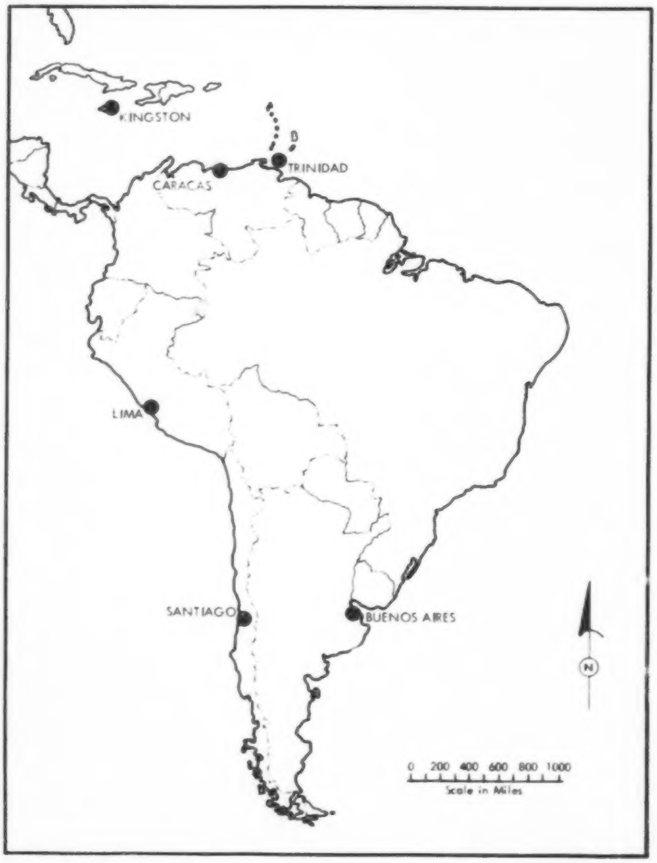

Figure 4. Pan American Air Network sampling stations

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(*1*) LOCKHART, L. B., JR., and R. L. PATTERSON, JR. Intercalibration of the major North American networks employed in monitoring airborne fission products, NRL Report 6025, Naval Research Laboratory, Washington, D.C. 20390 (December 1963); summarized in *Radiological Health Data*, 5:12–15 (January 1964).

(*2*) RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. Division of Radiological Health, Public Health Service, Washington, D.C. 20201 (Distribution by official request).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program. CNHW–RP–3, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*4*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program. CNHW–RP–4, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*5*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program. CNHW–RP–5, Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*6*) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program. RPD–11, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*7*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada. RPD–21, Department of National Health and Welfare, Ottawa, Canada (August 1962).

# Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

## STRONTIUM-90 IN HUMAN BONE, FIRST QUARTER 1965

*Division of Radiological Health*
*Public Health Service*

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in the United States in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium-90 in measurable amounts has been present in the global environment for more than a decade and major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium-90 content to be low and age-independent (*1*).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it is difficult to get so large a sample from infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for comparison to United Kingdom data have not been successful.

### *Laboratory procedures*

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Division of Radiological Health, at Winchester, Massachusetts. The collection and preparation of samples are described elsewhere (*2*). Strontium-90 is measured by TBP extraction of its yttrium daughter, which is precipitated as the oxalate. The strontium-90 content is then calculated from the yttrium-90 activity (*3*).

The results for strontium-90 in individual bones from persons dying during the first quarter of 1965 are presented in table 1. All data are summarized in table 2. The data are reported as picocuries of strontium-90 per gram of ash (the primary determination), per gram of calcium (for comparison with other data and for purposes of model development), and per gram of bone (as a rough indication of dose). Two-sigma counting errors are reported for the ash concentration. Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–4*).

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(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Rad Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Rad Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples chemical and radiochemical procedures NERHL 64-1 (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone. Rad Health Data 5:620-628 (December 1964).

**Table 1. Strontium-90 in human bone, first quarter 1965**

| Location of sample by region and State | Age at death (years) [a] | Sex | Bone type [b] | Strontium-90, pCi/g of: Ash | 2σ error | Ca | Bone |
|---|---|---|---|---|---|---|---|
| Northeast: | | | | | | | |
| Massachusetts | 2 | F | V | 3.15 | 0.25 | 8.90 | 0.34 |
| | 4 | M | V | 1.12 | 0.16 | 3.09 | 0.10 |
| | 5 | M | V | 1.38 | 0.13 | 3.94 | 0.10 |
| | 7 | M | V | 1.11 | 0.18 | 3.19 | 0.09 |
| | 14 | F | V | 1.43 | 0.08 | 3.79 | 0.18 |
| | 19 | M | V | 0.86 | 0.07 | 2.29 | 0.13 |
| | 20 | M | V | 1.01 | 0.09 | 2.73 | 0.12 |
| | 21 | F | V | 0.61 | 0.08 | 1.63 | 0.10 |
| | 24 | M | V | 0.70 | 0.06 | 1.81 | 0.10 |
| New York | 9 | M | V | 1.15 | 0.10 | 3.15 | 0.12 |
| | 11 | M | V | 1.16 | 0.10 | 3.17 | 0.10 |
| | 16 | M | V | 1.07 | 0.08 | 2.80 | 0.13 |
| | 17 | M | V | 0.93 | 0.09 | 2.47 | 0.09 |
| | 23 | M | V | 0.54 | 0.05 | 1.40 | 0.08 |
| Pennsylvania | 23 | M | V | 0.90 | 0.06 | 2.22 | 0.13 |
| Rhode Island | 2 | M | V, R | 1.72 | 0.18 | 4.53 | 0.17 |
| Central: | | | | | | | |
| Michigan | 2 | F | V | 2.06 | 0.18 | 5.68 | 0.19 |
| Minnesota | 8 | M | V | 0.99 | 0.11 | 2.75 | 0.10 |
| | 22 | M | V | 0.51 | 0.07 | 1.42 | 0.08 |
| Missouri | 16 | M | V, R | 1.09 | 0.07 | 2.69 | 0.27 |
| | 19 | F | V | 0.85 | 0.08 | 2.15 | 0.17 |
| Ohio | 2 | M | V | 1.86 | 0.14 | 5.06 | 0.18 |
| | 2 | M | V | 1.17 | 0.14 | 3.36 | 0.08 |
| | 3 | M | V | 1.30 | 0.11 | 3.63 | 0.10 |
| | 18 | M | V | 0.88 | 0.07 | 2.32 | 0.10 |
| | 23 | M | V | 0.59 | 0.06 | 1.52 | 0.08 |
| | 25 | M | V | 0.57 | 0.07 | 1.42 | 0.09 |
| Wisconsin | 4 mo. | M | V | 1.97 | 0.20 | 5.48 | 0.16 |
| | 8 mo. | F | V | 1.75 | 0.23 | 4.10 | 0.14 |
| | 1 | M | V | 1.62 | 0.14 | 4.38 | 0.14 |
| | 1 | M | V | 1.20 | 0.15 | 3.25 | 0.09 |
| | 2 | F | V | 1.88 | 0.18 | 5.69 | 0.14 |
| | 3 | M | V | 1.58 | 0.12 | 4.28 | 0.13 |
| | 4 | F | V | 1.35 | 0.13 | 3.71 | 0.11 |
| | 4 | F | V | 0.81 | 0.08 | 2.33 | 0.06 |
| | 5 | F | V | 0.94 | 0.13 | 2.54 | 0.08 |
| | 8 | F | V | 0.83 | 0.08 | 2.30 | 0.09 |
| | 8 | M | V | 0.50 | 0.05 | 1.39 | 0.04 |
| | 9 | M | V | 0.84 | 0.09 | 2.31 | 0.09 |
| | 13 | F | V | 0.56 | 0.05 | 1.58 | 0.06 |
| | 15 | M | V | 0.68 | 0.06 | 1.84 | 0.08 |
| Delta: | | | | | | | |
| Louisiana | 4 mo. | M | V, R | 1.67 | 0.14 | 4.38 | 0.20 |
| | 3 | M | V, R | 1.66 | 0.14 | 4.53 | 0.15 |
| | 3 | F | V, R | 1.36 | 0.14 | 3.68 | 0.12 |
| | 8 | F | V | 1.08 | 0.09 | 2.92 | 0.10 |
| | 13 | M | V | 1.28 | 0.09 | 3.49 | 0.13 |
| | 18 | F | V, R | 1.12 | 0.10 | 2.94 | 0.17 |
| | 22 | F | R | 0.40 | 0.06 | 0.99 | 0.07 |
| | 25 | M | R | 0.49 | 0.05 | 1.22 | 0.10 |
| Northwest: | | | | | | | |
| Alaska | 17 | F | R | 1.86 | 0.20 | 4.71 | 0.63 |
| | 22 | F | R | 0.51 | 0.10 | 1.28 | 0.16 |
| Washington | 7 | M | V | 1.01 | 0.14 | 2.77 | 0.10 |
| | 13 | F | V | 1.60 | 0.14 | 4.37 | 0.18 |
| Southwest: | | | | | | | |
| California | 6 mo. | M | V, R, S | 0.49 | 0.08 | 1.53 | 0.03 |
| | 1 | M | V, S | 0.97 | 0.09 | 2.69 | 0.08 |
| | 5 | M | V | 0.76 | 0.11 | 2.21 | 0,05 |
| | 5 | M | V, R | 0.64 | 0.08 | 1.81 | 0.54 |
| | 5 | M | V | 0.50 | 0.08 | 1.41 | 0.05 |
| | 8 | M | V | 0.48 | 0.06 | 1.33 | 0.04 |
| Texas | 4 | M | V | 0.88 | 0.15 | 2.47 | 0.07 |
| | 10 | F | V | 0.86 | 0.13 | 2.34 | 0.09 |
| | 17 | F | V | 0.55 | 0.07 | 1 46 | 0.07 |
| | 24 | F | V | 0.54 | 0.06 | 1.47 | 0.06 |
| | 24 | F | V | 0.36 | 0.06 | 0.99 | 0.03 |

[a] Age given as of last birthday prior to death for ages greater than 1 year.
[b] Type of bone: V, vertebra
S, sternum
R, rib

Table 2. Strontium-90 in human bone samples for 5-year groups 1961–1964 and first quarter 1965

| Age group [a] | Year of death [b] | Number | Strontium-90/calcium, pCi/g | | |
|---|---|---|---|---|---|
| | | | Mean | Minimum | Maximum |
| 0–4 years | 1961 | 3 | 2.7 | 1.8 | 3.4 |
| | 1962 | 50 | 3.3 | 0.8 | 9.7 |
| | 1963 | 44 | 4.5 | 1.0 | 13.0 |
| | 1964 | 67 | 4.4 | 1.0 | 8.7 |
| | 1965, first quarter | 21 | 4.1 | 1.5 | 8.9 |
| 5–9 years | 1961 | 1 | 2.7 | — | — |
| | 1962 | 33 | 2.7 | 1.0 | 9.4 |
| | 1963 | 43 | 3.9 | 1.8 | 9.1 |
| | 1964 | 64 | 3.6 | 1.2 | 7.0 |
| | 1965, first quarter | 14 | 2.4 | 1.3 | 3.9 |
| 10–14 years | 1961 | 4 | 1.8 | 1.2 | 2.8 |
| | 1962 | 28 | 2.1 | 0.8 | 3.5 |
| | 1963 | 47 | 2.9 | 1.3 | 9.0 |
| | 1964 | 56 | 3.1 | 0.9 | 5.7 |
| | 1965, first quarter | 6 | 3.1 | 1.8 | 4.4 |
| 15–19 years | 1961 | 0 | — | — | — |
| | 1962 | 31 | 2.2 | 0.9 | 4.6 |
| | 1963 | 73 | 2.6 | 1.0 | 7.0 |
| | 1964 | 58 | 2.9 | 1.2 | 8.0 |
| | 1965, first quarter | 11 | 2.5 | 1.5 | 4.7 |
| 20–24 years | 1961 | 0 | — | — | — |
| | 1962 | 29 | 1.8 | 0.9 | 3.5 |
| | 1963 | 61 | 2.2 | 0.9 | 5.0 |
| | 1964 | 52 | 2.2 | 0.8 | 4.3 |
| | 1965, first quarter | 10 | 1.6 | 1.0 | 2.7 |

[a] Ages taken as of last birthday prior to death
[b] Or surgical procedure

# ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Brookhaven National Laboratory and the Rocky Flats Plant.

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[1] Part 20, "Standards for Protection against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20442, on a subscription basis at $3.50 for 3 years.

170

## 1. Brookhaven National Laboratory
## July–December 1965

*Associated Universities, Inc.*
*Upton, New York*

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by discharge of coolant air from the graphite research reactor, (2) by radiation from an ecology forest gamma source, and (3) by the discharge of low-level radioactive liquid wastes into a small stream that forms one of the headwaters of the Peconic River (figure 1).

### *Area monitoring*

The radioactivity in the discharge coolant air is almost entirely due to argon–41, a beta-gamma emitter. Because exposure to argon–41 is due to external gamma, the monitoring is performed by measuring the exposure rate in milliroentgens per week (mR/wk) rather than the concentration in air.

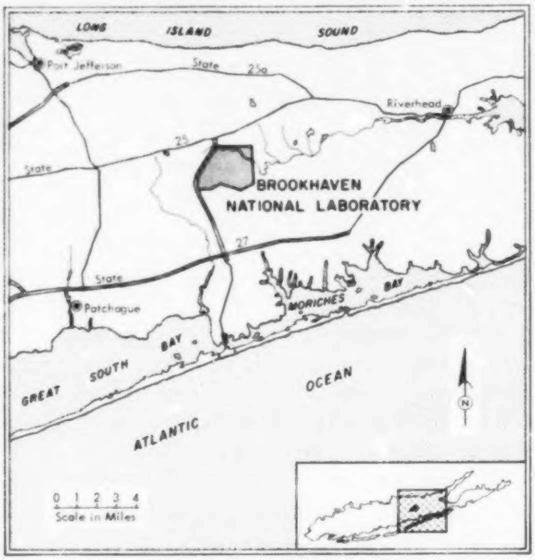
LONG ISLAND SOUND
Port Jefferson
State 25a
Riverhead
25
State
BROOKHAVEN NATIONAL LABORATORY
27
State
Patchogue
MORICHES BAY
GREAT SOUTH BAY
ATLANTIC OCEAN
N
0 1 2 3 4
Scale in Miles

**Figure 1. Brookhaven National Laboratory and surrounding area**

Late in 1961, a 10,000-curie cesium–137 gamma source was installed in the ecology forest about 800 meters equidistant from the north and east boundaries (*1*). The radiation levels resulting from the graphite research reactor effluent and the ecology forest source are monitored continuously by four stations located at the site boundary (figure 2).

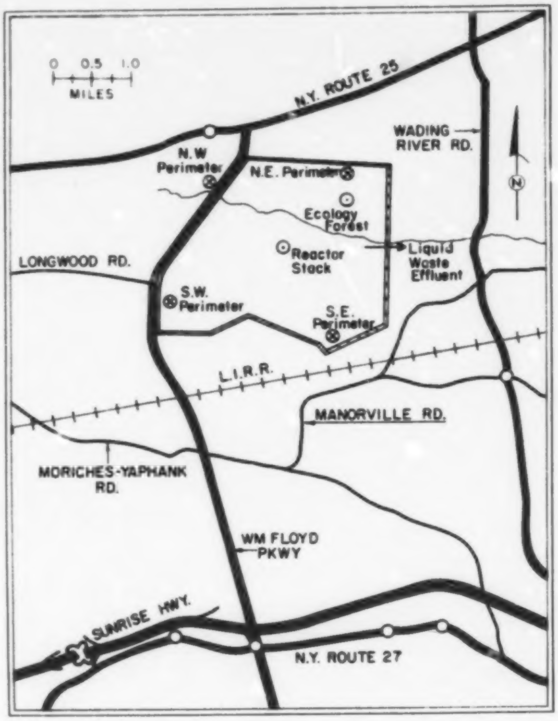
0 0.5 1.0
MILES
N.Y. ROUTE 25
WADING RIVER RD.
N
N.W Perimeter
N.E. Perimeter
Ecology Forest
Reactor Stack
Liquid Waste Effluent
LONGWOOD RD.
S.W. Perimeter
S.E. Perimeter
L.I.R.R.
MANORVILLE RD.
MORICHES-YAPHANK RD.
WM FLOYD PKWY
SUNRISE HWY.
N.Y. ROUTE 27

**Figure 2. Brookhaven National Laboratory monitoring station locations**

Radiation levels at the northeast perimeter are somewhat greater than at other monitoring stations due to the ecology forest source. However, the radiation levels at this location are within the AEC standard. The standard established by AEC is 0.5 rem/year for individuals in the population. The average weekly radiation levels at the Brookhaven National Laboratory site boundary, due to laboratory operations, are given in table 1.

Values of radiation background levels undisturbed by laboratory operations have been included in table 1 for purposes of comparison.

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[1] Part 20, "Standards for Protection against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

The ion chambers used in making these background level measurements are positioned 2 feet above the monitoring station roof. Measurements made in this manner are in close agreement with those made at 3 feet above the ground surface in the vicinity of the stations.

**Table 1. External gamma levels at BNL site boundary July–December 1965 and calendar year 1965**

| Period | Average exposure rates, mR/wk | | | |
|---|---|---|---|---|
| | North-west perimeter | South-west perimeter | South-east perimeter | North-east perimeter |
| Gamma exposure from laboratory operations: | | | | |
| Second half 1965 | 0.26 | 0.33 | 0.38 | 2.65 |
| July | 0.03 | 0.04 | 0.08 | 3.07 |
| August | 0.35 | 0.26 | 0.17 | 3.42 |
| September | 0.33 | 0.57 | 0.29 | 3.76 |
| October | 0.49 | 0.25 | 0.82 | 2.09 |
| November | 0.12 | 0.55 | 0.48 | 1.84 |
| December | 0.19 | 0.33 | 0.49 | 1.53 |
| First half 1965 | 0.23 | 0.13 | 0.61 | 2.27 |
| Calendar year 1965 | 0.24 | 0.23 | 0.49 | 2.46 |
| Average undisturbed background | 2.21 | 2.04 | 2.25 | 2.35 |

### *Water monitoring*

The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where it is discharged to the small stream. The values of concentration and activity in the stream where it leaves the site are computed on the basis of continuous measurements of the stream flow rate.

The gross concentration and amount of radioactivity in the laboratory's liquid waste effluent, as it leaves the site, are shown in table 2. Analysis of composite samples of the effluent has shown that, on the average, no more than 20 percent of the activity consists of strontium-90 and that no appreciable amounts of radioactive iodine or radium and other bone-seeking isotopes are present. Thus, were the BNL waste effluent to be used as drinking water, the applicable limit on the concentration, in accordance with the regulations of the Atomic Energy Commission, would be 1,000 picocuries per liter, averaged over a period of 1 year. However, the effluent does not enter directly into any drinking water supply and it undergoes considerable additional dilution as it progresses downstream. The average concentration value for the year, 38 picocuries per liter, is small relative to the permissible concentration.

**Table 2. Gross beta activity in BNL liquid waste effluent July–December 1965 and calendar year 1965**

| Period | Average beta concentration (pCi/liter) | Total beta activity discharged (mCi) |
|---|---|---|
| Second half 1965 | 36 | 19.3 |
| July | 34 | 3.2 |
| August | 29 | 3.3 |
| September | 28 | 2.6 |
| October | 34 | 3.0 |
| November | 31 | 2.5 |
| December | 65 | 4.8 |
| First half 1965 | 41 | 22.4 |
| Calendar year 1965 | 38 | 41.8 |

Recent coverage in *Radiological Health Data:*

| Period | Issue |
|---|---|
| July–December 1961 | June 1962 |
| January–June 1962 | January 1963 |
| July 1962–June 1963 | February 1964 |
| July 1963–June 1964 | December 1964 |
| July–December 1964 | June 1965 |
| January–June 1965 | December 1965 |

## 2. Rocky Flats Plant
## July–December 1965

*Dow Chemical Company*
*Golden, Colorado*

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location relative to population centers is shown in figure 3. To assure properly controlled release of radioactive materials to the environment, periodic samples of water, air, and vegetation are analyzed for gross alpha activity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized Front Range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

### *Air*

Continuous 24-hour air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The gross alpha activities which are shown in table 3 as monthly averages are believed due to naturally occurring materials.

**Table 3. Long-lived alpha activity in particulates in air, RFP**

| Period | Average alpha concentration (pCi/m³) |
|---|---|
| July | <0.006 |
| August | <0.006 |
| September | 0.009 |
| October | 0.009 |
| November | 0.009 |
| December | <0.006 |

Concentration limit—0.04 pCi/m³

### *Water*

In addition to regular water samples obtained from four reservoirs, nonroutine raw surface water samples were collected from a number of outlying streams and lakes along with vegetation samples. Results of alpha activity analyses are given in tables 4 and 5.

**Table 4. Alpha activity in water collected from reservoirs in the vicinity of RFP and outlying surface waters July–December 1965**

| Reservoir | Average alpha concentration (pCi/liter) |
|---|---|
| Great Western | 2.2 |
| Standley | 2.1 |
| Baseline | 2.5 |
| Ralston | 3.2 |
| Raw surface waters (collected June 1965) | 2.7 |

**Table 5. Alpha activity in vegetation, calendar year 1965**

| Distance from plant | Number of samples | Average alpha concentration (pCi/kg dry weight) |
|---|---|---|
| <3 miles | 58 | 72 |
| 3–18 miles | 44 | 61 |

Recent coverage in *Radiological Health Data:*

| Period | Issue |
|---|---|
| July 1962–June 1963 | February 1964 |
| July 1963–June 1964 | December 1964 |
| July–December 1964 | June 1965 |
| January–June 1965 | December 1965 |

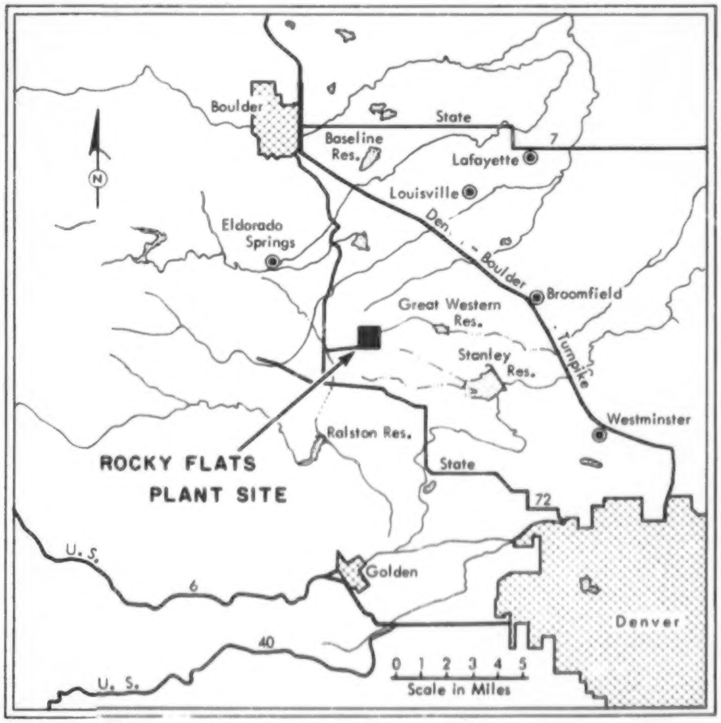
Boulder
State
7
Baseline Res.
Lafayette
Louisville
N
Eldorado Springs
Den.-Boulder Turnpike
Broomfield
Great Western Res.
Stanley Res.
Westminster
Ralston Res.
ROCKY FLATS PLANT SITE
State
72
U. S.
6
Golden
Denver
40
U. S.
0 1 2 3 4 5
Scale in Miles

**Figure 3. Location of the Rocky Flats Plant environment, Denver, Colorado**

# Section V. Technical Notes

## REPORTED NUCLEAR DETONATIONS, MAY 1966

During May 1966, the Atomic Energy Commission announced seven underground nuclear tests at the Nevada Test Site. Tests conducted on May 4, 5, 12, and 27 were of low yield (equivalent to the force of less than 20 kilotons of TNT), and tests conducted on May 6, 13, and 19 were of low-intermediate yield (equivalent to the force of 20 to 200 kilotons of TNT).

Communist China's third nuclear explosion, occurring on May 9, 1966, was estimated to be in the lower end of the intermediate yield range (equivalent to the force of 200 kilotons to 1 megaton of TNT). Preliminary analyses of the debris from this test indicated that the device contained no plutonium but employed enriched uranium. Some lithium–6 was present, but its function is not clear.

# SYNOPSES

**Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.**

COLORADO DENTAL X-RAY MACHINE SURVEY, 1961–April 1965. *R. W. Alcox, R. A. Downs,* and *P. W. Jacoe. Radiological Health Data and Reports, Vol. 7, June 1966, pp. 319–325.*

Results of a two-phase program for examining dental X-ray machines showed marked progress by the dental profession in correcting equipment and procedural deficiencies identified by mail-order surveys and physical surveys conducted by the Colorado State Department of Public Health. The first phase of the program was a "Surpak" mail-order survey and the second phase was a physical survey, using standards recommended by the U.S. Public Health Service for X-ray beam diameters, filtration of the primary beam, beam definiton, and leakage. Following the first phase of the study, the number of machines having beam diameters of 2.75 inches or less increased from 48 to 73 percent; following modifications during the physical survey phase, 85 percent of the machines met the standards. Improvement in meeting filtration standards is shown in a rise from 25 percent compliance during the first survey to 74 percent. During the physical survey, many areas of dental radiographic practice were examined and specific changes were made or recommended to minimize exposure to both patients and dental personnel. The most common procedural errors observed were overexposure and inadequate development of film.

*KEY WORDS:* collimation, Colorado, dental, development, equipment, exposure, film, filtration, standards, Surpak, survey, X-ray.

RADIOACTIVITY IN MILK IN THE UNITED KINGDOM, 1962–1965. *R. S. Bruce. Radiological Health Data and Reports, Vol. 7, June 1966. pp. 326–330.*

Radiochemical analyses of raw milk produced in the United Kingdom showed that in 1962 the total iodine-131 in milk was about 85 percent of that found in the autumn of 1961; subsequently, levels have remained below the limit of detection. Concentrations of strontium-90 and cesium-137 increased sharply in 1962 and again in 1963, reaching maximum levels in the middle of the year. Since then, apart from seasonal fluctuations, there has been a general decrease in contamination. The annual average ratio of strontium-90 to calcium in milk in the United Kingdom increased from 5.9 pCi/g in 1961 to 28 pCi/g in 1964, and fill to 19 pCi/g in 1965. The mean concentration of cesium-137 changed similarly, the values for 1964 and 1965 being, respectively, 153 and 98 pCi/liter.

*KEY WORDS:* cesium-137, England, iodine-131, milk, strontium-90, survey, United Kingdom.

RADIONUCLIDES IN THE UNITED KINGDOM DIET, 1962–1964. *R. S. Bruce. Radiological Health Data and Reports, Vol. 7, June 1966, pp. 331–334.*

In continuing United Kingdom diet studies, a fourfold increase in strontium-90 contamination of the average diet has been observed between 1961 and 1964. The ratio of strontium-90 to calcium in the average mixed diet in 1964 was 25.9 pCi/g (corresponding to an intake of 28.5 pCi/day), which is nearly three times the value in 1959. During 1962 to 1964, the relative contributions of strontium-90 from different types of food remained fairly constant. Cesium-137 levels increased markedly between 1961 and 1963, the estimated daily intake, based on assays of five types of food, rising from about 30 to 170 pCi/day; in 1964 the value was 160 pCi/day. Measurements of strontium-89 and barium-140 during 1962 and 1963 indicated that these nuclides were minor radioactive contaminants of the diet.

*KEY WORDS:* barium-140, cereals, cesium-137, cheese, eggs, flour, meats, milk, strontium-89, strontium-90, survey, tea, United Kingdom, vegetables, water.